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FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 17 Number 1

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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Forest Service, Washington, D. C.

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PAPER BAGS FOR AERIAL WATER BOMBING OF FOREST FIRES

A. P. LESLIE AND J. D. NICHOLS
Division of Research, Ontario Department of Lands and Forests

The Ontario Department of Lands and Forests became sufficiently interested in the possibility of forest fire suppression by bags of water dropped from aircraft to conduct field tests in the Sault Ste. Marie district in 1949. This form of attack showed definite merit and was developed into an efficient aid in fire suppression operations.

Water bombing of forest fires is selective and the effectiveness is limited, but it is felt that this practice can play an important part in the suppression of forest fires and will continue to do so until such time as helicopters are readily available.

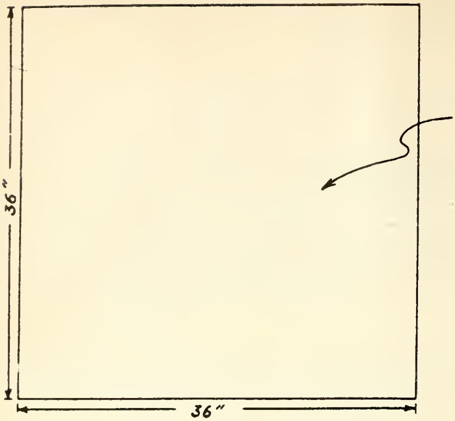
This attack is primarily intended to retard the rate of spread of small forest fires in situations that are difficult to reach on the ground. Under such conditions it may slow down the fire until suppression crews reach the area. The method has been found effective also in assisting fire fighting crews in bringing portions of the fire edge of large fires under control and has proved quite good on these fires during the early hours of the morning. Assistance to the suppression crew is carried out through the medium of air-to-ground and ground-to-air communication and care is taken that no bombs are dropped until the suppression crew has retired from the target area.

The water bombing of small, inaccessible fires generally follows a set pattern. The aircraft lands on the nearest water, two smokechasers are dispatched to the fire, a third man is kept to assist the pilot in the water bombing operation. The water bombing equipment is installed, 17 to 24 bombs are filled with water, and the bombing begun. Bombs are dropped in salvos of up to eight per salvo.

The water bombing equipment used in the standard De Havilland Beaver aircraft of the Department consists of conveyer, camera hole fixture, water bombs, and pail for filling water bombs. Description of this equipment and procedure followed during bombing operations is available in a technical bulletin, Aerial Water Bombing Instructions, issued by the Ontario Department of Lands and Forests.

The water container bag or "water bomb" is manufactured to Department of Lands and Forests specifications, as illustrated in the accompanying diagrams, by a specialty firm who assisted and worked with the Department on the development of this bag. Fifty- and sixty-pound wet strength Kraft papers, plasticized and coated with a self-seal adhesive compound are used in the manufacture of the water container bag. The properties of the adhesive compound make the bag waterproof and supply a quick and efficient method of sealing.

Diagram 1



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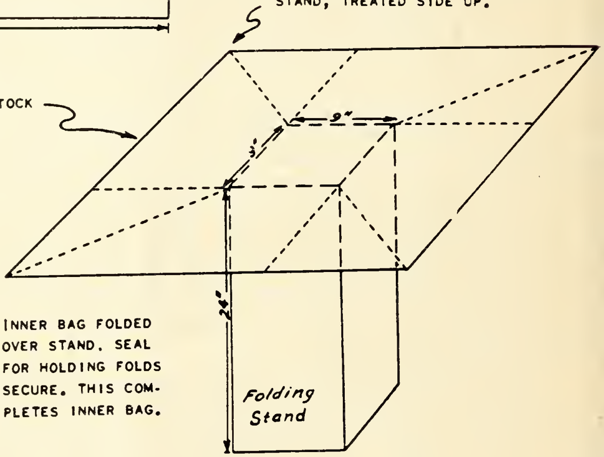

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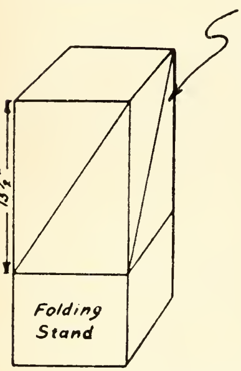

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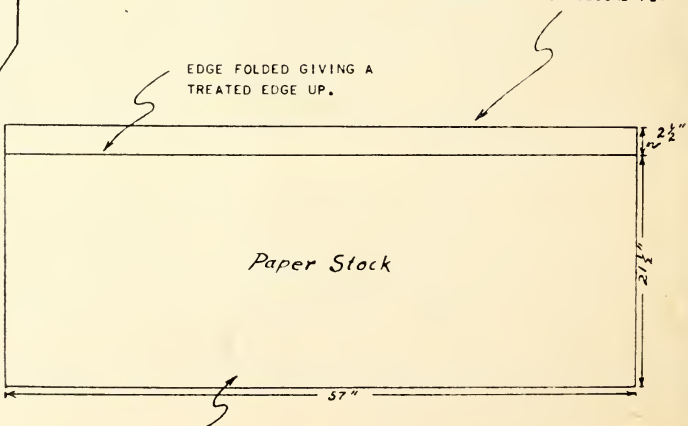

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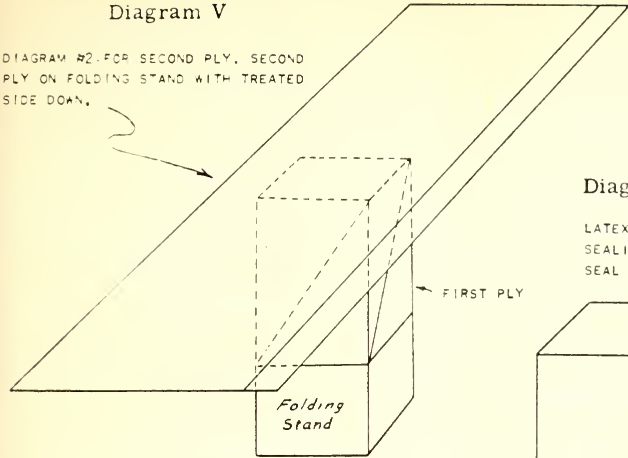


Diagram VI

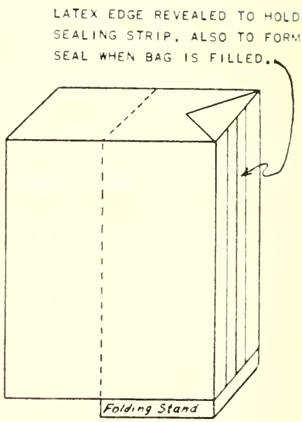


Diagram VII

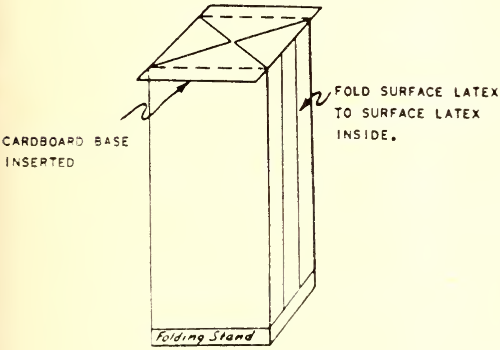


Diagram IX

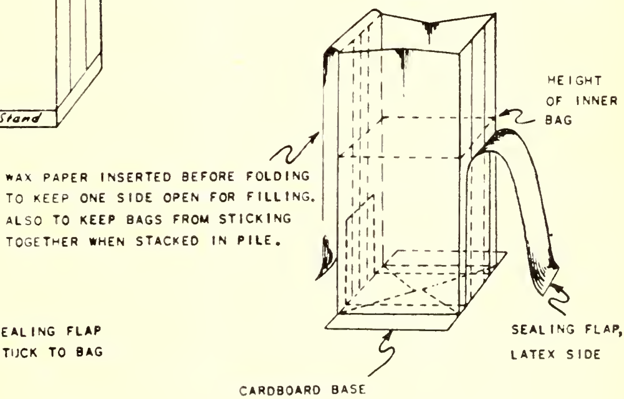


Diagram VIII

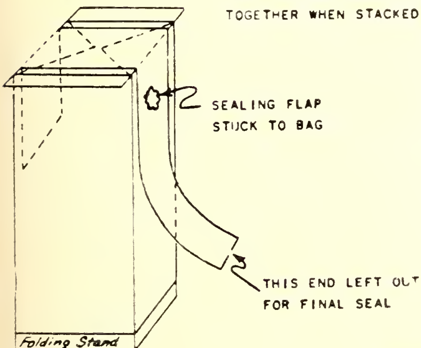
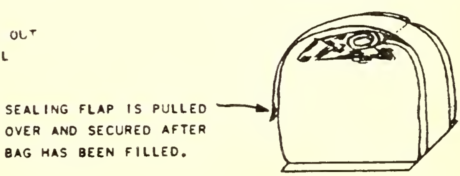


Diagram X



On the top 7 inches of the bag, the sealing compound is on the inside of the paper and forms the watertight seal when closed. This seal is prevented from sticking before use by the insertion of a piece of waxed paper that is removed and thrown away when the bag is filled. The compound is between the two layers of paper on the rest of the bag which is the container section.

To give rigidity when filled, a piece of treated cardboard is held to the base of the bag by the sealing flap as shown on the accompanying diagrams. Correct folding of the outer ply of paper forms a sealing strip on the side opposite the flap side.

When the bag is filled with water the top section is sealed and folded down onto the top of the container section and held in this position by attaching the sealing flap to the sealing strip. Filled and sealed correctly the bag roughly resembles a cube. Specification details are as follows:

Paper		Kraft, wet strength.
Inner ply		60-pound.
Outer ply		50-pound.
Self-seal compound		Latex.
Dimension of base of bag	inches	9 x 9
Dimension of cardboard	do	9 x 11
Height of bag	do	18
Width of mouth opening	do	9
Width of sealing flap	do	7
Width of sealing strip	do	4
Dimension of bag when filled	do	11 x 11 x 11
Capacity of bag	gallons	3.5

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Fire Finder Maps: Protected, Yet Kept Up-to-Date

Most methods of protecting the maps on top of fire finders require coating with transparent liquids or impregnation as in the Lamacoid process. The disadvantage is that once the map is treated no changes can be made either in the road locations or in the ownership status. To overcome this disadvantage we have used the following method. It is cheap, easy to use, not messy. Changes can be made on the base map as often as needed.

The untreated base map, after it has been mounted on the map plate, is covered with a sheet of heavy glass called "crystal sheet" in the glass trade. This is almost as heavy as plate glass, but much cheaper; a 20-inch circular piece costs $4.65 at today's prices. The untreated map is mounted on the circular, removable base of the Osborne fire finder with rubber cement. We remove the center pin used to center the map in order to eliminate the need for having a hole bored in the glass. The map is oriented in the usual manner, and the screws tightened down. Then the piece of crystal sheet glass is placed over the map. This protects the map yet may be readily removed so that changes can be made.—A. J. QUINKERT, *District Ranger, Wayne-Hoosier National Forest.*

PROSPECTS OF EXTINGUISHING FIRES FROM THE AIR

A. A. Brown
Chief, Division of Forest Fire Research, U. S. Forest Service

Aircraft have participated in varying degrees in forest fire fighting since 1919. At first, use was limited to detection or verification of the existence and location of small fires and to aerial reconnaissance of large going fires.

We did some experimenting in the late thirties on the possible effectiveness of spraying or bombing fires with water and other extinguishers. We found at that time that free liquids released from a plane dissipated so rapidly in the air that very low flying would be required. Mountainous terrain, turbulent air, and poor visibility due to smoke ruled this method out at the time. Preliminary tests of water bombing showed some promise, but the low capacity of planes available and the lack of suitable facilities discouraged operational use.

However, experimental and other test work at this time demonstrated the feasibility of delivering men and equipment close to a fire in roadless country by parachute. Intensive work was done in developing suitable parachute equipment and methods that could reduce safety hazards of such an operation and that could make it a feasible substitute for numerous but widely disseminated, seasoned ground fire fighting forces. This was accomplished in 1940 to a degree that "smokejumpers" and aircraft became a regular part of the forest fire fighting organization for the large blocks of roadless forest country that exist in parts of Idaho, Montana, Washington, Oregon, northern California, and New Mexico. The complete story of smokejumping is separately available.

Further development of aerial methods of detecting fires has also taken place and the substitution or supplementing of fixed lookout systems by regular patrol from the air has proved its value, particularly where lighting fires are prevalent and forest fuels are relatively slow burning.

These uses of airplanes are successful and are now well established. In addition, small helicopters have come in for increasing use for shuttle service on large fires. Their ability to move key men or critically needed equipment up a mountain slope or across rugged terrain in minutes compared to hours, and their ability to land in a small, hastily prepared spot are such valuable assets, that high cost of such service, limited carrying capacity, and their inability to carry sizeable loads when operating from landing spots at high elevations, have not prevented fire agencies from taking advantage of their capabilities. But these uses are primarily a matter of aerial transportation. The attractive possibilities of utilizing helicopters and fixed-wing airplanes to fight fires directly have not developed very far to date.

In 1947 a renewed effort was made to develop aerial bombing of forest fires as a joint project with the Air Force. The purpose was to test the effectiveness of such methods and to develop equipment and technics adaptable to military planes and operations. Good results were obtained on small fires with large water bombs exploded at treetop heights dropped from B-29's and modified wing tip tanks dropped from P-47's by skip or dive bombing technics. In typical forest fuels, fires of ¼ acre or less were never fully extinguished but the spread was stopped and burning was held down to a point where there was ample time for a small ground crew to get to the fire in an inaccessible location to complete the job. The effect on large fires was less encouraging with the methods used.

In 1948 the propeller drive fighter bomber aircraft used successfully in bombing small fires became obsolete for military purposes. At that time new jet type fighters were not believed suitable for such missions in mountainous areas. Because of priority of military requirements it was not considered practical for the Air Force to commit a fleet of bombers with crews in the degree of readiness necessary for further tests on an operational basis. For such reasons, the Air Force withdrew from the experiments leaving many questions unanswered.

Since that time many economic and technological changes have occurred that justify a new look at all possibilities. Timber and watershed values and cost of fire protection by ground methods have increased enormously. The cost of aerial operations has not increased in the same proportion. Similarly, plain water delivered through a nozzle onto a going fire is no longer "cheap." So new "expensive" additives that can increase its extinguishing power might pay off handsomely. The capabilities of aircraft have been enhanced and the tactical and strategic measures that they might carry out successfully need not be confined to bombing.

If dropped in sufficient mass, water can be delivered in an effective pattern from much higher flight levels than we have previously believed possible. Plastic or paper envelopes might serve in other situations and large carrying capacities might offset to a considerable degree what has formerly been regarded as a prohibitive cost of transporting water in the volumes necessary to have a definite effect on a fast-burning fire front. Usually, it would be necessary to apply ¼ to ½ inch of water per unit area to most of the burning area to have much effect.

If a standard of this order is assumed, the prospects of directly extinguishing a large fire that has assumed conflagration proportions appear quite remote. An airplane with a 2,500-gallon load of water or liquid extinguisher might accomplish it for an area of only a half acre or less. Larger capacities such as possessed by the C-74 or C-124 would increase the possible area of coverage. But it is apparent that a prohibitively large fleet would be necessary to have a positive extinguishing effect on a large fast-moving fire of several thousand acres. Such a fire sets up violent convection currents which also create dangerous hazards to aircraft. For

these reasons even large capacity for carrying extinguishers does not offer a ready solution to such situations.

In spite of such limitations, there are critical situations in the early spread of every fire when extinguishing action at the right time and place on only a portion of its perimeter would insure prompt control of the fire at great savings in damage and fire fighting costs. Too often such action is beyond the resources of ground fire fighting forces in rugged terrain.

It is for these reasons that even limited but timely action from the air offers attractive possibilities. To realize such possibilities in emergency operations, we believe a systematic research and development program, including a series of extinguishment tests, will be necessary. So far personnel and facilities available for such purposes have been too limited to enable a satisfactory rate of progress.

In 1953 disastrous fires in southern California focused attention again on the need to develop new and better methods of reducing the disastrous losses inflicted by runaway fires. All fire agencies in that area volunteered help in organizing a project to test out a number of unconventional methods and ideas. Since defense against such fires is also a grave problem in civil defense, the Federal Civil Defense Administration gave sponsorship and six branches of the Department of Defense gave assistance in various ways. With this remarkable pooling of resources and interest, an ambitious and highly successful one-year exploratory project, known as Operation Firestop, combining field and laboratory tests was carried out.

They demonstrated that new chemical retardants have possibilities of effective application from the air, that water in sufficient volume, can be released suddenly from a modified torpedo bomber and delivered on a fire with considerable accuracy without undue loss in the air, that small helicopters have many tactical possibilities for laying hose, and for first-aid action in fire fighting that have not been exploited, and that large helicopters can deliver men and fire pumps with water to any part of a fire in rugged topography at will and can apply water to a fire at close range.

This has been a fine start. Of necessity Firestop had to be largely exploratory. Few of the new things tried could be developed to a point where they could be applied directly by fire agencies. Much further research and development is needed. It will be costly. It calls for a much stronger research staff than has so far been available to the Forest Service. But there is so much loss and human suffering at stake and the problem is so important to wartime defense that many are optimistic that ways will be found to solve the many problems that still exist in making fire fighting from the air a new stage in the progress of forest fire control.

The prospects of extinguishing a fully developed conflagration from the air are still not encouraging. But there are excellent prospects of preventing such a conflagration from developing by early aerial action. The prime advantage of aircraft is in their

capability for speed and for access, which can increase success in taking action at the right time and right place. Inability to do so at critical times is the major handicap of ground forces under conditions of heavy cover and rugged terrain. Much may be accomplished by "first aid" from the air at the moment a fire is on the point of escaping from ground forces.

The many small but timely actions that might be taken directly from the air to help the fire fighter on the ground to win more victories can be summed up in military terms as *giving close aerial support* to *ground fire fighting*. Most forest fire fighting agencies agree that a full program of research to develop aids in this way and to develop new methods is very much needed.

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METEOROLOGICAL PROBLEMS ASSOCIATED WITH MASS FIRES

DeVer Colson
U. S. Weather Bureau

Weather plays an important role in the behavior of mass fires. The knowledge and understanding of the meteorological conditions existing prior to and during these fires are essential for efficient fire fighting and control in both urban and rural situations. Ordinary fires or even large fires which are burning and spreading in a regular manner do not present the major control problems. Serious situations often develop when what seems to be a routine fire suddenly intensifies or begins to spread at a greatly increased rate or changes its direction of spread abruptly. In forestry parlance, the term "blow-up" or "explosive" has been applied to such forest fires since these fires often seem to explode. However, many fires have been designated as "blow-ups" simply because of a lack of understanding of the factors controlling the behavior of these fires.

There is much to be learned both in identifying these factors and in forecasting the occurrence of these factors. Some of the possible meteorological factors will be discussed briefly in this paper.

General burning conditions.—Most serious fires occur with extremely low fuel moisture caused by severe or extended drought conditions. These conditions are usually combined with high surface temperatures and low relative humidities and often with strong surface winds.

One notable example involved the famous Chicago fire on October 8, 1871, and the associated fires in Wisconsin and Michigan on the same day which burned over 1,000,000 acres, including the entire town of Peshtigo where over 600 lives were lost. Weather data indicate extreme dryness and strong winds on that date. On days with less hazardous burning conditions, these fires might well have been controlled before they had reached such disastrous proportions.

In the preparation and planning for the fire bombing raids over the Tokyo area, weather conditions were studied in connection with brush fires in North Carolina, a region climatically similar to the Tokyo area. The following factors were used: precipitation, relative humidity, and maximum wind speed. The maximum wind speed on the day of the fire was used while the precipitation and relative humidity were weighted over the day of the fire and the three previous days. These same factors are used directly or indirectly in most current fire danger rating systems.

Surface wind patterns.—The details of the surface wind patterns are necessary for efficient fire fighting operations. These details would include: the actual local surface wind patterns; the diurnal variations in these patterns; and the dependence of these local patterns and their diurnal variations on the surface pressure patterns as well as frontal and storm passages, the upper level weather patterns, atmospheric stability, wind and temperature profiles, and topography.

A knowledge of the local wind patterns and their variations is even more essential in areas of rugged terrain. In these areas, there are the additional effects of general drainage patterns (mountain and valley winds) and the diurnal up- and downslope winds due to the differential heating of the slopes. The relative influences of all these factors vary greatly with the ruggedness of the terrain.

Two local wind surveys have been conducted, one by the U. S. Weather Bureau in 1949-52 at Oak Ridge, Tenn., and the other by Operation Firestop in 1954 at Camp Pendleton, Calif. Unfortunately, much of the data from these surveys cannot be applied to other areas because of the influences of the local terrain and weather conditions. However, as data from additional surveys are accumulated, more and more generalizations can be made that can be applied to other areas. Such wind studies are important in air pollution and smog control.

It is the unusual cases that cause the most trouble. Some recent cases are the 1949 Mann Gulch in Montana and the 1953 Rattlesnake and 1954 Sierra City fires in California. At each of these fires, fire fighters lost their lives when the fire spread rapidly in an unusual and unexpected manner. In the Mann Gulch fire, the unusual currents may have been due to the strong surface winds resulting from descending currents from the high level thunderstorms in that area. In the other two cases, the rapid spread of the fire may have been due to a combination of the normal night downslope air drainage acting simultaneously with a pressure gradient across and through the passes. As more is learned about these wind patterns, more of these unusual fires and their behavior patterns can be anticipated.

Topography.—With the proper pressure gradient across mountain ridges and through passes, strong local winds will be set up as the air flows down the lee side. Examples of such strong local winds are the Santa Ana winds in southern California, the east winds in western Oregon and Washington, and the chinook winds on the east slopes of the Rocky Mountains. These winds have a tremendous effect on fires since they are associated with high temperatures and low relative humidities.

Upper level winds.—As fires spread into the crowns of high trees, a different rate of spread can be expected since the wind speed and direction at this level may be quite different from that near the ground. Also, with burning buildings, the surface winds may have little connection with the fire spread at higher levels. With convection currents carrying burning embers up into even higher levels, the rate and direction of the spread of the fire due to spotting may be entirely different from that which would be expected from just a knowledge of the surface winds alone.

Turbulence.—In addition to the actual local wind patterns, the turbulence or the fluctuations in both the wind speed and the direction must be considered. The magnitude and frequency of these fluctuations have been found to be closely associated with the degree of atmospheric instability. Also, the magnitude and

frequency of these fluctuations will be greater at well exposed sites than at well sheltered locations. Mechanical eddies and turbulence can be generated as air flows across and around sharp features of terrain and buildings.

Convection.—Under certain atmospheric conditions, better convection can be sustained which will promote more efficient burning. These conditions are usually associated with atmospheric instability, that is, with near or superadiabatic temperature lapse rates. However, the convection column will not attain great heights if the wind speed increases too rapidly with height. Too strong a wind speed may cause the column to be broken away from its energy source.

Temperature inversions tend to act as a lid on free convection. However, under these conditions, as the free air temperature reaches a certain value or as the energy of the fire becomes great enough, the convection can break through the inversion and can suddenly extend to much greater heights, especially if the atmosphere is unstable above the inversion. When this breakthrough occurs, sudden changes will take place in the fire behavior and the spread.

Much experimental and theoretical work is now in progress on the general problems of turbulence, diffusion, convection and allied problems at many air pollution and micrometeorological projects.

Thunderstorm and lightning.—The high level and often dry thunderstorms present a great hazard in the Rocky Mountain area because of lightning fires. Project Skyfire has been set up in the Northern Rocky Mountain area to study the origin, development, structure and intensity, movement, distribution of these storms, and the possibility of modification of these storms to reduce the lightning hazards.

Meteorological phenomena induced by a large fire.—Once a fire develops, the original wind and temperature distribution around and over the fire will be changed. A complete study of this problem requires accurate and detailed data on temperature, humidity, wind speed and direction, and the composition of the gases in the convection column. From these results, it will be possible to determine the rate of transfer of heat, momentum and the distribution of energy about the fire. In addition to experimental studies at actual fires, much information has been gained from model studies.

Strong indrafts, usually referred to as the firestorm have been observed in the vicinity of some large fires and may become quite appreciable at times.

Conclusion.—As more is learned about the meteorological factors as well as a better knowledge of the fuel distribution and efficiency of combustion, fewer fires will be designated as "blowups." These fires can be anticipated and their behavior patterns expected. However, a vast amount of difficult experimental and theoretical work will be necessary to accomplish this goal.

FIRE EXTINGUISHERS, THEIR TYPES AND USE. IV. FOAM EXTINGUISHERS

A. B. Everts

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In appearance the foam hand extinguisher resembles the soda-acid extinguisher. It operates in the same manner—by inverting the container to mix the chemicals, which builds up pressure for discharging the foam.

Foam is essentially a Class B extinguishing agent, but it is also effective on Class A fires. In certain types of Class A fuels, such as excelsior, rags, overstuffed furniture, etc., foam is not apt to bring about complete extinguishment because it will not penetrate. Reignition will probably occur. It will help to control, but not extinguish, such fires. Foam should *not* be used on Class C fires.[1]

There are two intriguing characteristics of foam: its expansion, and its insulating qualities. The 2½-gallon foam extinguisher, which is the one we generally think of as a hand extinguisher, will produce 20-22 gallons of foam with a projection of 30-35 feet from the discharge hose. The foam will cling to vertical surfaces, thus providing insulation from the flames. There are instances of 40-gallon foam units that have stopped the spread of well-involved Class A fires by insulating adjoining buildings from the flames. The fire was not controlled, in the general sense, but it was contained.

The foam produced by hand extinguishers should not be confused with the foam used by the fire departments, oil refineries, and naval craft where large volumes of foam are required. That type of foam is a liquid which is mixed with the water at the rate of 6 percent. A special type of nozzle is required. The method of generating foam in the hand extinguishers, or even the 40-gallon wheeled type, is quite different.

The chemical charge contains two packets. One of these, bicarbonate of soda and a foam stabilizing agent, is dissolved in water outside the extinguisher and then placed in the outer compartment. The other charge, aluminum sulfate, is dissolved in water and placed in the inner shell.

When the extinguisher is inverted the two chemicals mix and the resultant reaction generates carbon dioxide gas. Unlike the soda-acid extinguisher, however, the discharge, because of the aluminum sulfate, is foam.

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[1]For more information on classes of fires and types of extinguishers see: *Fire Extinguishers, Their Types and Use. I. Carbon Dioxide Extinguishers II. The Dry Chemical Extinguishers,* and *III. Water-type Extinguishers,* by A. B. Everts. Fire Control Notes 15(4): 1–5, illus. 1954; 16(1): 9–12, illus 1955; 16(2): 24–26, illus. 1955.

Sizes of extinguishers.—Hand extinguishers are nearly always of the 2½-gallon size. Wheeled "engines" are usually manufactured in 20- and 40-gallon sizes. Formerly the hand extinguishers were made of drawn copper. New models are made of stainless steel and drawn brass and are tested to 500 pounds' pressure.

How to use the extinguisher.—Carry the extinguisher to the fire. Upend it to start the chemical reaction. For Class A fires direct the stream at the burning material or coat the burning surface.

Because of the insulating characteristics of foam the extinguisher is a good one to use along with a typical Class A extinguisher—soda acid or loaded stream. While one operator applies water directly on the fire, a second operator can insulate the adjacent material by the application of foam.

On Class B fires the method of application varies: on gasoline or oil spills the foam is applied direct; but on fires in open vats or tanks the best method of application is to direct the foam stream against the inside wall of the vat or tank just above the burning surface, so as to permit the foam to spread back over the burning liquid. Extinguishment is by smothering.

Maintenance.—Foam extinguishers should be recharged annually. All parts should be washed thoroughly with water. Check to make certain that the hose is not clogged. Commercial recharges cost about $2.50, if done in a dealer's plant, but the recharge chemicals can be purchased for about 50 cents. If you do your own recharging, mix the chemicals in accordance with the instructions on the packages.

FIGURE 1.—Cutaway photograph of a foam extinguisher showing the inner container.

WARNING: Do not use antifreeze ingredients in a foam extinguisher. To do so will reduce the effectiveness of the discharge and may result in internal corrosion which will make the extinguisher dangerous to use.

Foam extinguishers need to be protected from freezing.

Summary.—Foam extinguishers (a) should be used on Class B fires, secondary on Class A fires; (b) need annual recharging at a commercial cost of $2.50 or a do-it-yourself cost of 50 cents; (c) cost around $30 (charged); (d) have length of discharge stream of 30-35 feet; (e) produce 20 gallons of foam; (f) will freeze (Note: Do not use antifreeze salts).

A CASE FOR SIMPLIFIED FIRE EXTINGUISHERS[1]

CALVIN H. YUILL

Director, Fire Technology, Southwest Research Institute

Have you ever tried to use a fire extinguisher only to find that it was designed for a different kind of fire? Or discovered that a particular extinguisher operated differently from any that you had used before? Or breathed the deadly fumes generated in using some extinguishers? Or spilled acid on your clothing while servicing another type of extinguisher? All of these mishaps, and worse, have happened to many people.

Most fires could be stopped in their early stages by judicious use of a hand fire extinguisher. Prompt action by an alert employee could save his job and his employer's business. It is estimated that nearly a third of all fires—more than two-thirds of fires in industry, are extinguished with hand operated fire extinguishers.

This record is impressive when considered by itself. In relation to the annual toll of fire, it loses much of its significance.

Our direct fire losses today amount to over a billion dollars a year and indirect losses are several times that figure. Some 12,000 people lose their lives in fire and thousands more are severely burned each year. Every possible means of reducing these fire losses is worth considering. Simplification of the design of fire extinguishers is one avenue of approach that would be worthwhile.

There are eight types of fire extinguishers commonly sold today. Five can be used on fires in ordinary combustibles such as wood, cloth, paper and rubbish. Five are available for use on burning oils, greases and other flammable liquids. There are three types available for fires involving electrical equipment.

Some extinguishers can be used on two different kinds of fire. None can be used successfully on all three.

Confusion Confounded

Among the eight basic types of extinguishers are a multitud of operating techniques. One recent publication of a recognize laboratory illustrates four methods of actuating carbon dioxid extinguishers and five methods for operating dry-chemical extin guishers. Here indeed is confusion confounded. Is it any wonde that many fires get out of hand while the bewildered worker trie to figure out the method of operating a particular extinguisher.

Recognizing the value of present-day fire extinguishers, it believed their utility could be measurably increased if the eigh types could be reduced in number and the operating mechanis standardized.

[1]Reprinted from *Tomorrow Through Research*, by permission of Sout west Research Institute, San Antonio, Tex.

Let us explore the possibility of reducing the number of fire extinguishers by examining well established characteristics of each. Extinguishers for fires in ordinary combustibles are a good starting point.

The common soda-acid extinguisher is probably the oldest and most widely used. This unit, however, must be inverted so that the sulphuric acid will mix with the bicarbonate of soda solution to generate gas to expel the mixture. It must be emptied, washed and recharged each year using care to avoid spilling the acid. It is good only for fires in ordinary combustibles.

Foam extinguishers operate much as the soda-acid type but with aluminum sulphate in place of sulphuric acid and a stabilizer is added. The same objections to method of operation and maintenance apply plus the fact that the sticky foam solution is hard to clean up after the fire is extinguished. This extinguisher is suitable for use on both combustile and flammable liquid fires. Since the solution is conductive, it should never be used on fires involving electric equipment.

Another extinguisher is the "loaded stream" type. Here a proprietary liquid is expelled by gas from a pressurized cylinder. There is a wide divergence of opinion on the merits of this extinguisher and it is not recognized by one of the two large laboratories engaged in testing and approving fire extinguishers. It also can be used on combustible and oil fires but not on fires in electrical equipment.

Another common type is the water pump tank. For outdoor work—on grass, brush or trash fires—this is unexcelled because it can be refilled quickly and kept in constant operation. However, the pump tank requires more maintenance than many types and is not convenient for use on indoor fires.

The charged water extinguisher uses pressurized gas or a small gas cylinder inside the body of the unit and plain water. This type of extinguisher is easy to use, clean and simple to maintain. Again, it is limited to use on fires involving combustibles.

Simplicity Is Possible

From a purely functional point of view, the number of extinguishers for use on fires in combustibles could be reduced from five to one.

Now let us look at the five extinguishers sold for use on oil, grease or gasoline fires. As we have just seen, the foam and "loaded stream" types have definite drawbacks.

The vaporizing liquid extinguisher using either carbon tetrachloride or chlorobromomethane as the extinguishing agent can be purchased from the mail order house, the corner drug store or neighborhood hardware store. Few of the people selling or buying this type of extinguisher realize the high toxicity of fumes produced by the liquids used. Many health and medical authorities condemn this type of extinguisher. We would do well to eliminate it from the list.

This leaves the carbon dioxide and dry chemical extinguisher: and a choice between these two is difficult. For many, the carbo dioxide extinguisher is attractive because it leaves no residue. O the other hand, trained fire fighters often prefer the dry chemica type for certain fires because of its lesser tendency to "flash back' with use.

Finally there are three common types of extinguishers recom mended for electrical fires. All three can be used on oil fires, an have been considered already. Leaving out the vaporizing liqui extinguisher for reasons already stated we have left the carbo dioxide and dry chemical types.

We have then eliminated five of the eight common types of fir extinguishers for use in buildings and have left only three:

1. Charged water extinguishers for fires in combustibles.
2. Carbon dioxide and dry chemical types for oil and electrica fires.

Since the last two types are rather close in performance, it i quite possible that one of the two could be adopted as a standard Exhaustive testing under a wide variety of conditions would b necessary to establish a preference.

A Plea for Uniformity

Actually, substantial differences in performance do not exis and selection of any one type for each of the three kinds of fire is based largely upon personal preference.

Now how about the operating mechanisms of these basi types—could they be standardized? The answer is an unqualifie yes, and such standardization is not only possible but has alread been done.

One manufacturer has on the market charged water, carbo dioxide and dry chemical extinguishers that are practically ider tical in appearance and operation. The method for operating ther is so simple that it is obvious even to the uninitiated.

There are many reasons that would explain the present situ tion. Tradition, customer demand, or competition, would impec a change in established practices. Nevertheless, from the viev point of public safety, much would be gained from the transitio Confusion in customers' minds would be eliminated and the sta set for much wider use of this important fire fighting device.

Here indeed is a challenge to industry. An opportunity to ser the public better and to expand markets at the same time. At t same time thought should be given to further improvements su as lighter weights, better design—even an all purpose extinguis ing agent. These things will come in time—the opportunity f simplification is here today.

BUNK TOOL RACK

LLOYD E. MYERS
Forest Fire Warden, Division of Forestry, Ohio Department of Natural Resources

Storing handtools in a warehouse is frequently a problem. Fire rakes, for instance, can be dangerous when hanging from the wall. One solution is the bunk tool rack. It is cheap, and can be easily moved from one place to another (figs. 1 and 2).

The frame is made of 2 by 4's in the form of a double bunk bed. Four pieces 6 feet long serve as side rails, 4 pieces 36 inches long as legs, and 4 pieces 32 inches long as crosspieces. The bottom and top rails are 22 inches apart. Cyclone wire stretched and stapled over top and bottom rails will hold fire rakes, broom rakes, swatters, axes, shovels, and about any other handtool used in fire fighting.

Where there are large numbers of tools to be stored, bunks can be laid on their sides and stacked one on top of the other, or stood on end to save space.

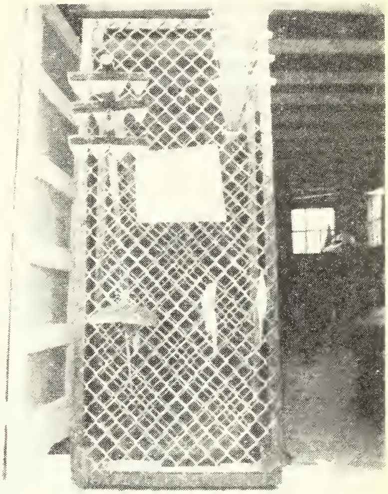

FIGURE 1.—Rack on end.

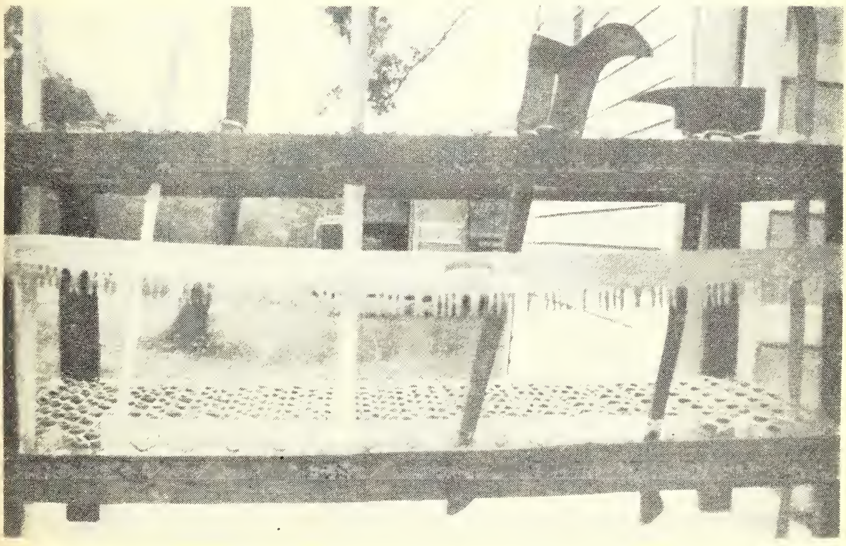

FIGURE 2.—Bunk tool rack in normal position.

FIRE SUPPRESSION UNIT FOR THE SMALL FOREST

DON M. POST
Assistant Professor, School of Forestry, University of Florida, Gainesville, Fla.

At a cost of less than $700 this fire protection unit may be the solution to your problem. This machine was designed for farmers and owners of small forests who can't justify a high capital outlay for fire protection equipment.

Tractor drawn, the unit has a 325-gallon tank with a 1-inch, high-pressure centrifugal pump and a 6-horsepower, air-cooled motor (fig. 1). The pump is capable of delivering 5 to 65 gallons per minute at 20 to 140 pounds pressure, 16 minutes supply of water at full spray at 20 gallons per minute. A gear type pump

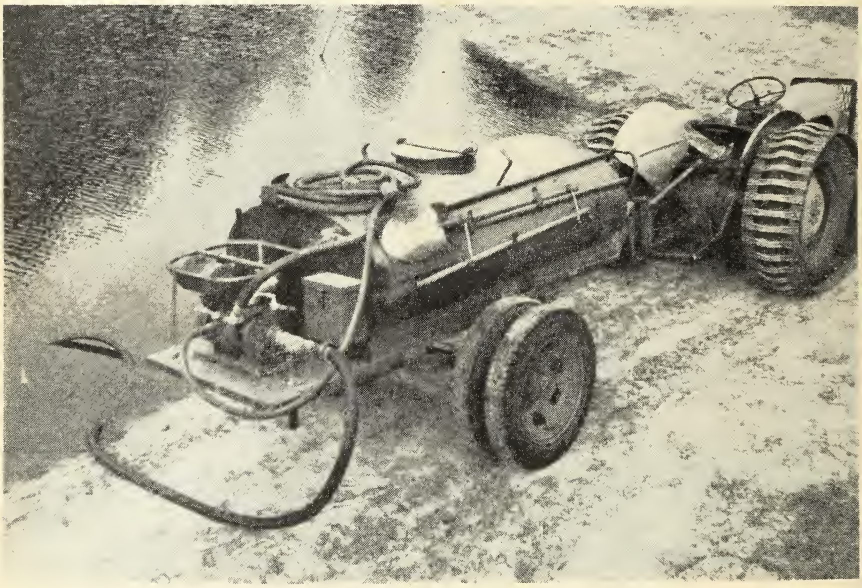

FIGURE 1.—Suppression unit ready for use. At a 10-foot lift the tank can be filled in 7 minutes.

and motor, or power takeoff arrangement on the tractor could be substituted for the centrifugal pump and motor at a substantial reduction in cost. However, when the tank is to be refilled from streams or pond with sandy bottoms the gear type pump may not be satisfactory.[1]

[1]Further details concerning the construction of this tanker-trailer may be obtained by writing the author.—Ed.

The unit weighs 654 pounds empty, 3,324 pounds fully loaded. It can be towed easily by a medium-size farm tractor through most woods areas. For use along woods roads a pickup truck would be suitable (some States require trailers grossing over 1,500 pounds be equipped with approved brakes).

Forest fire suppression is only one use to which this unit lends itself. It can be used to protect farm buildings or could serve as a supplementary unit for the fire department of a small community. It can also be used to irrigate small nurseries or gardens, or clean logging or farming equipment.

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Ash-Tray Smokey Bear

The life-size Smokey Bear poster makes a very good "Use ash tray" fire prevention sign that is also handy at service stations. The cut-out Smokey and cubs are mounted on plywood with a large "Please Prevent Forest Fires" across the bottom. At Smokey's left paw is mounted a gallon oil can, with "Empty Ash Trays Here" above it. The plywood is cut ¼ inch larger than Smokey and dark brown paint is used to trim. A transparent sprayed-on plastic coating to preserve Smokey is planned. The sign stands by itself and is placed in a convenient location. Demand for the signs exceeds supply.—MILO PETERSON, *Area Forester, Iowa Conservation Commission.*

CANOE SMOKECHASER TOOL UNIT

W. W. Wentz

District Ranger, Green Mountain National Forest

Smoke chasing along the relatively inaccessible fourteen miles of shoreline of the Somerset Reservoir in the Green Mountain National Forest is most effectively carried on by canoe transported crews. In waters frequently quite choppy for canoe travel a unit was necessary to provide safe transportation of tools in the limited space available and to protect the somewhat fragile structure of the canoe from damage. A lightweight, compact unit was constructed to provide these safeguards as well as to speed up the time involved in launching the fully equipped canoe (fig. 1).

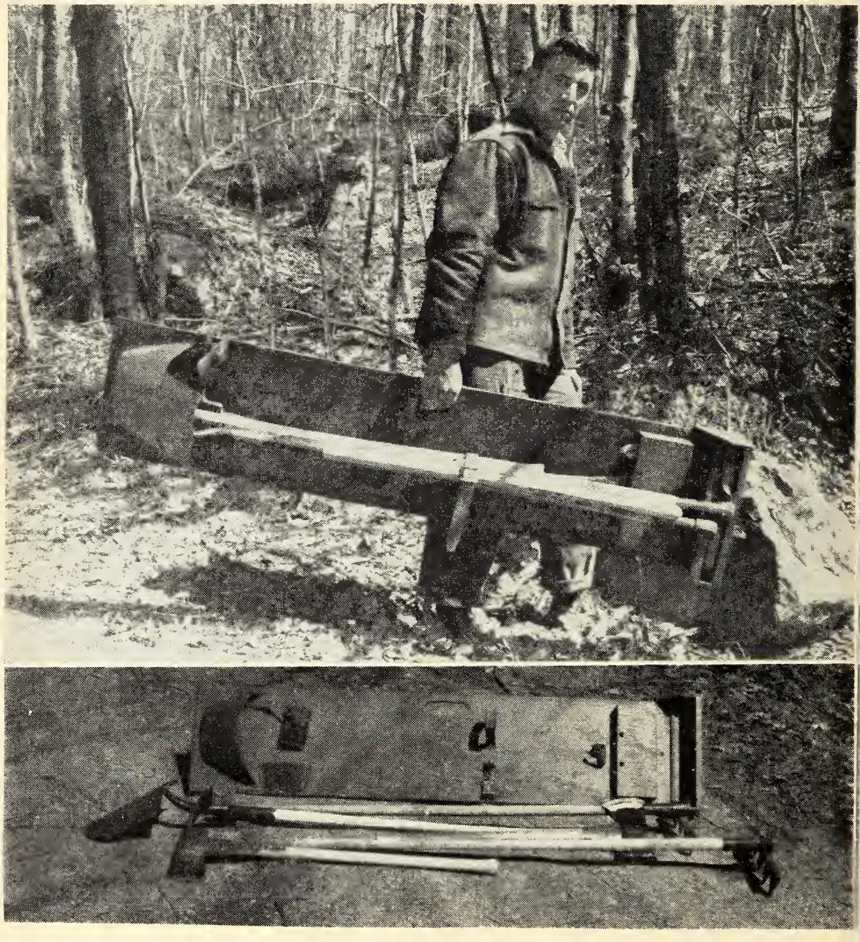

Figure 1.—Smokechaser tool unit designed primarily to lie flat in a motor-driven canoe.

On a base of salvaged 3/8-inch fir plywood a sheet of light gage metal was formed around the head of a shovel and tacked in place. A light plywood box the size of a double-bitted head was screwed to the board and a buffer strip of 1- by 3-inch spruce was fastened to the end of the base to prevent the council tools from sliding. Another piece of light metal was formed around the ax bit of the pulaski tool under the shovel handle and tacked in place. The other head of the pulaski tool was sheathed in a single-bitted ax sheath which is secured to the board. In the center of the board a short length of leather strap with a buckle was screwed and a "U" bolt placed to receive a snap swivel on the end of the strap. The strap firmly secures all tools together and on the board. A carrying handle has been cut at the balance point of the unit for ease of carrying.

The unit as designed fits a local need for use in a canoe with a 3-man capacity but could be well adapted to provide a lightweight complete unit placed in other types of vehicles on a temporary emergency basis.

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Coronado Fire Camp Table

Until recently the Coronado National Forest fire camp table consisted of an assorted pile of lumber, cut to various lengths and put together at the selected camp with hammer and nails. This did not produce a very serviceable table and there were far too many pieces of lumber to keep track of. Oftentimes, the carpentry was not of the best. It was decided that something better might be designed. The table now used on the Coronado is considered far superior, goes together in a fraction of the time, and is far sturdier. It is made as follows:

Cut in half a piece of 3/4-inch plywood; 4 by 10 feet is a good size though it may be larger or smaller. Join the two pieces, which are 4 by 5 feet, with two heavy strap hinges, about 12 inches long. Attach 1/2-inch pipe flanges near all corners of both pieces of the plywood; cut eight pieces of 1/2-inch pipe to about 32 inches, threaded on one end. It is very important to use stove bolts that fit the holes in the hinges and the flanges, and to secure the nuts by lightly riveting them. The hinges should, of course, be mounted on the underside of the plywood so they are not in the way on the tabletop. If single tables are desired hinges are not necessary.

To set up the table, simply screw the pieces of pipe in the flanges, turn the table over, and it is ready for use. No tools are needed to set up the table, hand twisting of the pipes is ample.

To transport the table in a truck or pickup, fold the two sections together and tie the pieces of pipe in a bundle. The whole thing takes up very little room; several tables may be carried if desired.—GILBERT SYKES, *District Ranger, Coronado National Forest.*

PROTECTOR FOR HOSE ACROSS ROADS

Rolfe Anderson
District Ranger, Siuslaw National Forest

In 1954 District Assistant Willis Horner and District Ranger Rolfe Anderson of the Hebo District devised a protector for hose lines lying across roads where traffic must be kept moving during the operation of a pumping system.

The hose protector was constructed from 4 pieces of 4- by 12-inch spruce plank cut 42 inches long, beveled on the ends for easy crossing by trucks, and with a cutout through the center to accommodate one or two 1½-inch hose lines. For dual-tired vehicles such as logging trucks double planks are necessary. These may be hinged so they will stay parallel and in place while in use and yet can be folded for ease in transporting (figs. 1 and 2).

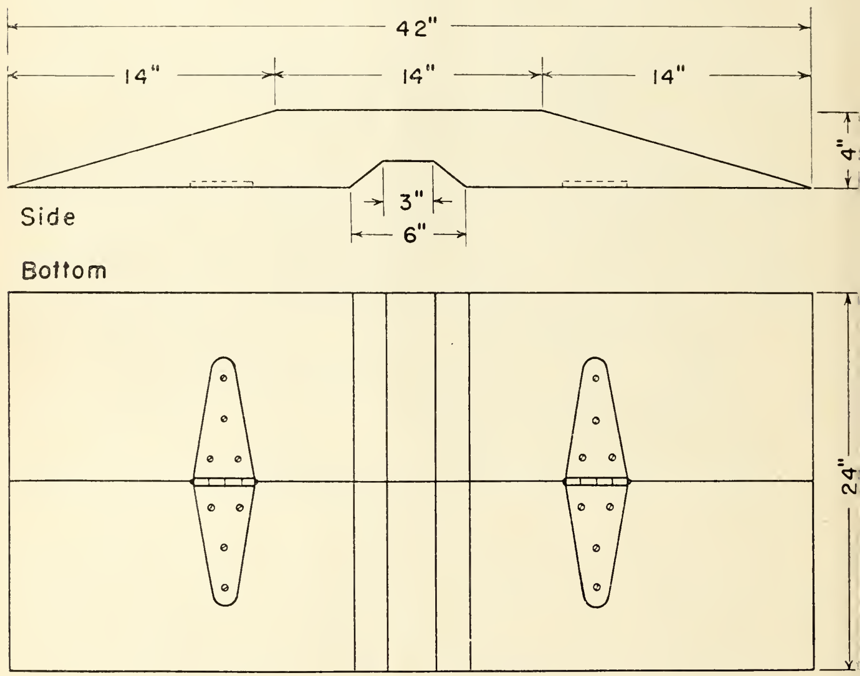

Figure 1.—Hose protector construction details.

These hose protectors have proved their value on the Hebo Ranger District and elsewhere on the Siuslaw; they fill a definite need on slash burning operations or fire fighting when it is necessary to lay hose across roads without interrupting traffic, or risk

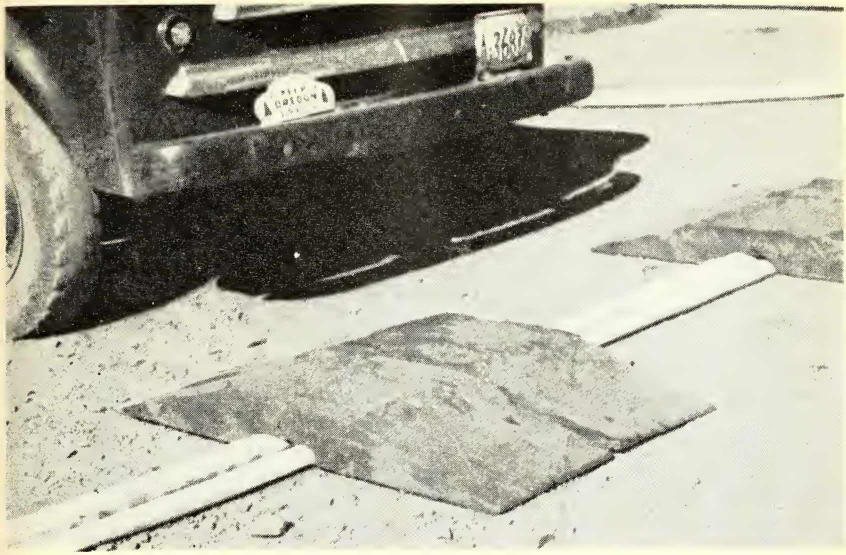

FIGURE 2.—Hose protector in place.

ing broken hoses. Two primary values are simplicity of construction and the fact that, once in place, they "stay put" without the constant attention so commonly needed with planks and other usual protectors.

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Stop Power Saw Fires Tags

In order to reduce the number of man-caused fires started in Oregon's forests by power saws the Keep Oregon Green Association has prepared a red tag, approximately 3 by 6 inches, listing fire precautions. Quantities of this tag will be distributed to power saw agencies and their repair shops in Oregon so that a tag can be attached to each power saw sold or repaired. District wardens, U. S. forest rangers, and U. S. Bureau of Land Management foresters will have tags for distribution, and the State Forester plans to include one in every envelope that contains an operating harvesting permit for 1956.

These are the fire precautions for power saws listed on the tag:

1. Place power saw on mineral soil when fueling, NOT in dry litter or slash.
2. Permit hot power saw to cool two or three minutes before refueling.
3. Use non-spill gas can to fill tank and avoid spilling of inflammable fuel.
4. Use proper oil and gas mixture to minimize carbonization.
5. Do not start power saw at place of filling.
6. Keep power saw clean of sawdust and inflammable material.
7. Keep muffler on the power saw and in good condition.
8. Don't operate your power saw if it is backfiring.
9. Keep spark plugs and wire connections tight.
10. Keep a filled fire extinguisher and shovel with power saw at all times.
11. Clear inflammable material from point of saw cut.
12. Put out any fires started and report them to the foreman, together with causes.
13. All fires should be promptly reported to the proper forest protection agency.—ALBERT WIESENDANGER, *Executive Secretary, Keep Oregon Green Association.*

TELEVISION TESTED FOR FOREST FIRE DETECTION IN CALIFORNIA

JOHN HASTINGS

State Forest Ranger, California State Division of Forestry

As a part of its program of equipment development and research, on June 7-10, 1955, the California State Division of Forestry participated with the Hancock Electronics Corporation of Oakland in a test and demonstration of closed circuit industrial television as adapted to forest fire detection.[1] This demonstration served the twofold purpose of acquainting the Division of Forestry with the possibilities of television for forest fire detection and demonstrating to the manufacturers some of the requirements of a good fire detection system and the ability of their equipment to fulfill these requirements.

No specific equipment was developed for this test and all equipment used was that which had been previously developed for other uses. However, it was stated that a complete installation embodying any features that we might desire could be constructed.

Prior to the test, a platform was constructed at the 90-foot level of a 100-foot steel lookout tower 200 feet from our El Dorado Ranger Unit headquarters. The platform was constructed so that it projected out about 5 feet beyond the west side of the tower and permitted a camera sweep of about 270 degrees free from interrupting tower girders and framework.

The television installation consisted of a television camera, control unit, and monitor mounted upon the tower platform and linked by coaxial cable to three 12½-inch monitors in the nearby dispatch office. Of the three monitors in the dispatch office, one was used by the lookout-observer, one was used with a 4 x 5 Speed-Graphic camera to record what was observed upon the monitor screen, and one was used to film a limited amount of 16-mm. movie film.

In this demonstration, all camera movement was controlled by the lookout-observer using a small remote control unit adjacent to the monitor. The remote control unit consisted of a small box with two momentary switches, one moved up or down for tilt control and one moved left or right for azimuth control (fig. 1).

As there was no provision for registering the azimuth at which the camera was pointed, it was necessary that the lookout-observer be able to orient himself by familiarity with the terrain as it appeared upon the monitor screen. In order to aid in this orientation and to facilitate evaluation of the scene viewed, prior to the start of viewing, all of the permanent mill smokes in the area and

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[1] Several other States have made or are making similar tests. Louisiana is now operating a TV lookout alongside a manned lookout for a season's evaluation. Two problems still to be solved are (a) more definite determination of the effectiveness of TV observations at maximum distances, and (b) best method for indicating azimuth, a requirement that has a direct bearing on cost of an installation.

FIGURE 1.—Monitors used in viewing by TV lookout-observer and in taking pictures of scene observed; remote control unit on desk.

certain terrain features were plotted upon a map and identified as to distance and azimuth from the camera. In addition, possible points for the ignition of test smokes were located.

During the period of the test and demonstration, observing was done using 8-, 16-, and 20-inch focal length telephoto lenses (fig. 2). With each lens, prominent terrain features and all of the permanent mill smokes in the area were observed and photos of their appearance upon the monitor screen were made. The mill smokes were located at varying azimuths and at distances of 6 to 16 miles. Test smokes were ignited at distances of 7, 10, and 13 miles to test the ability of the lookout-observer to pick them up. In all instances, when the test smokes were ignited, the camera was pointed in the direction of the expected smoke.

Results of this limited test have indicated to us that the television camera is a feasible means of fire detection although at this time we did not have the opportunity to make a firm comparison between the merits of a manned lookout tower and a TV-observer. Further tests will be needed to determine the comparative efficiency of each method as well as the relative costs of each system.

The 8-inch lens appeared limited to about 10 miles for picking up small smokes and detail although the field of vision seemed good for routine scanning. The 16- and 20-inch focal length lenses brought detail at distances not reached by the 8-inch lens, but they were not satisfactory for scanning. Haze penetration was improved by the use of an improvised filter.

Best results would appear to be obtained by the use of a camera with a multiple lens installation—a 6- to 8-inch focal length lens for general scanning rotated at a rate such that the observer can spot small smokes with a minimum of difficulty and

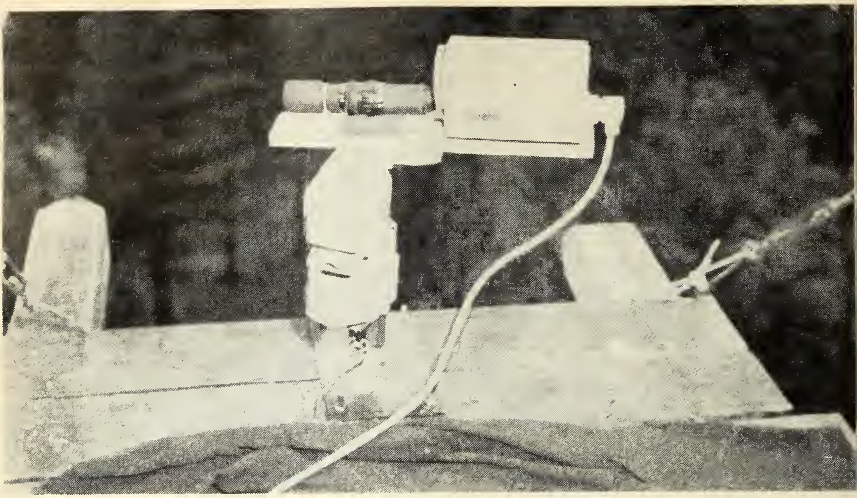

FIGURE 2.—TV camera with 8-inch focal length telephoto lens installed.

a lens of 16- to 20-inch focal length for close scrutiny of specific areas, particularly out towards the edge of the 15-mile radius. Use of proper filters will probably materially improve the visibility during hazy conditions.

Some problems that still need to be solved are these:

1. What is the best lens to use for routine scanning considering field of vision and magnification.

2. Given the desired lens, what is the optimum rate of scanning that will permit satisfactory coverage of the area and easy observation of small smokes.

3. What are the desirable filters to use.

4. How many monitors can one observer watch and what are the fatigue factors involved.

The various problems encountered during this test were discussed with the manufacturers. None of them appear to be insurmountable. As the problems are overcome, it is the intent of the California Division of Forestry to continue to evaluate the television camera as a means of providing a primary detection service or supplementing the existing system.

ACCIDENT FACTORS ARE "DANGEROUS DOMINOES"

JOSEPH RADEL

Safety Officer, Region 5, U. S. Forest Service

[Adapted from a talk given by the author at the California Region's 1955 Supervisors Meeting at San Francisco.]

A well-known author in his book on industrial accident prevention used dominoes to illustrate accident factors. We have borrowed the idea but adapted it to Forest Service use. If these principles of dangerous dominoes are understood they can be further adapted to our use so that current gains in safety will be continued. There is every good reason, in fact, to look forward to the day when Region 5 will practically eliminate accidents. But first let us look back at our injury frequency rate.

There has been a constant downward trend in injury rates since 1947. From 38 lost-time accidents per million man-hours worked in 1947 to just slightly over 10 in 1954 for an all time low represents a 74 percent reduction in injury frequency. This constant betterment in our record of employee safety represents hard work, ingenuity, and leadership by many people in the Region.

It has been said, "There is no hope for the satisfied man." We believe it true for us in safety, too, so our goal is an injury frequency of 5 or less. By process of extrapolation we can extend the present average trend to show that by 1959 the Region should be below 5. This means less than 30 lost-time accidents annually for the entire Region. A worthy objective which, when reached, will mean we have eliminated much suffering, grief, and financial hardship for our people.

One of the most successful salesmen in America lists determination and willingness to pay the price as qualities needed to achieve our goals, whether it be in our personal or official life. We can reach our goal in safety if we want to eliminate injuries enough to make accident prevention a vital part of all activities.

Accident factors occur in a given sequence to produce a final result. Like dominoes standing in a row when the first is tipped over it will cause the rest to fall successively. Injury or death is the final domino. Preceding the injury is occurrence—an accident which may or may not cause an injury. (For example, the top coming out of a burning snag, which narrowly misses the fire fighter, is an accident but in this case doesn't result in injury. The next time a similar occurrence might cause a fatality.)

Preceding the occurrence or accident there is in every case either an unsafe act of a person or persons (such as carrying an ax on the shoulder or using a file without a handle) or an unsafe physical or mechanical condition (unguarded machinery, mushroomed striking tools, etc.) or both. Back of these stand several more dominoes—the reasons for the unsafe act or hazardous condition. Sometimes we refer to these dominoes as "the cause behind the cause." So we have our train of dominoes on end, culminating in an injury. Our aim is, of course, to discover the key dominoes which cause accidents and remove them.

Key Dominoes

Environment, heredity, habit: these are the first three dominoes. They influence production as well as accidents. Environment is defined as "the external conditions and influences which affect the life and development of people." These influences, for good or bad, make their impact before the Forest Service gets the employee. Certainly there is no question about hereditary traits, those physical characteristics transmitted from parent to offspring. Habits, good or bad, are also pretty well ingrained by the time we hire an individual. Does this mean we are helpless? No, I don't think so. Our choice here falls within a solid recruitment program, and like the two poles of a battery has a positive and negative side. Positive will result in development of methods to attract the best, whether they be seasonal or year-round professional and nontechnical people; negative, in rejecting those not fit for Federal service whether it be for a few weeks or for a lifetime career.

Recruitment

In presenting a guide for a positive program of recruitment Clare Hendee, our former regional forester, said, "Recruitment of qualified people who can be trained to give loyal, efficient public service is one of the Region's basic problems. We all agree that public service goals will best be achieved with and through good people . . ." He also listed several recruitment factors, such as (1) attitude which demands the best; (2) arrest records held to a minimum; (3) physical exams for employees; (4) standards of discipline kept high but fair; (5) set a right climate for growth and satisfaction on the job; (6) faith in the willingness of able employees to be loyal and enthusiastic.

In Region 5, seasonal personnel outnumber yearlong personnel two to one. Counting turnover we hire more than 3,000 seasonal workers each year. Many of these come from the city where they have had little or no opportunity to observe us or our work. Integrating such workers into the Forest Service for top public service is extremely difficult. Job training, orientation, supervision and, perhaps most of all, safety become a tremendous challenge to those of us who supervise. Thus we can't afford the additional handicap of using inferior parts when trying to weld a striking force together under these circumstances. Perhaps we can't always compete salarywise with private industry, but we can use our ingenuity to sell other desirable benefits and opportunities available to employees who work for the Forest Service.

We no longer automatically get the best forestry graduates from the schools. A prominent forestry school recently wrote us concerning this very problem. Despite the urging of the entire forestry school staff, less than half of the students took the "JF" examination in 1954. "A decade or two ago," the dean said, "most of our students wanted a Forest Service career. Today this is changed. Private industry is competing for and getting some of the best forestry graduates."

The same situation holds true for engineering graduates. This situation means many things in terms of recruitment ingenuity—such as adequate housing, treatment on the job, climate favorable to growth, and satisfaction on the job. It will also have to mean full appreciation of student employment as a significant step in recruitment of year-round personnel. For, after all, how we treat the student and the opportunities and challenges presented during summer employment may be the deciding factor as to whether or not he desires to make the Forest Service his career.

Unsafe Conditions

Here we have one of the less subtle dominoes. An unsafe mechanical or physical condition is simply defined as "a condition which might have been guarded or corrected." From the standpoint of accident prevention this is the one sequence factor most easily corrected or changed. We have done well in eliminating this deadly domino but not well enough. I have yet to go on one forest without finding at least several instances where safety engineering could be improved. Last year I found these "unsafe conditions" which could have been eliminated but which were not: Unguarded belts, inadequate machine guarding, mushroomed tools and other defects of tools, unsafe overhead storage, poor lighting, poor housekeeping, no goggles sent out to a fire for use with grinders, ungrounded electrical equipment, electrical outlets and pull chains accessible from shower stall, dangerous location of garage in relation to a busy transcontinental highway.

Unsafe Acts

An unsafe act or faulty behavior is usually associated with some degree of physical hazard. Thus this dangerous domino is usually found in combination with other equally dangerous dominoes. In the Forest Service, however, regardless of the good job we might do in safety engineering we still have the steep slope, burning snags, rolling rocks, explosive brush fires, scaling logs at a busy landing, driving trucks and cars over winding mountain roads, and many other highly hazardous jobs.

Obviously we cannot level the slope or put a machine guard around a man to protect him from rolling rocks if his job causes him to be on a steep rocky slope. Nor can we at this stage in our development of fire fighting techniques prevent the smoldering brush fire from taking off when weather factors are right. Therefore, in the Forest Service, we must not only know and practice commonly accepted safe procedures but, in addition and under certain circumstances, we must be familiar with the techniques of "injury avoidance." There is a difference. Let me illustrate.

A worker uses a power grinder. Since he can finish the job in about 3 seconds he makes a decision not to use the goggles. He takes a chance and a piece of steel flies into his eye, causing a painful and lost-time injury. He definitely committed an "unsafe act" by violating a commonly accepted safe procedure—in this

case his decision not to wear goggles. An unsafe act can be some-thing a person does or something he should not have done o perhaps done differently. He may have done so deliberately with full knowledge that he was doing something unsafe or he may no have known. The criterion here is usually "would a cautious an well-trained person have done the same thing under the sam circumstances" or in the above example used the grinder withou goggles?

Good injury avoidance techniques can be illustrated by th precautions a well-trained fire boss will take when leading hi men down to a spot fire in brush. Under certain circumstances h knows that such action would be suicide. Therefore, before h takes his men in on such a mission he considers wind, humidity slope, density of brush, escape routes, lookouts, experience an physical condition of his men. His personal action in taking hi men to such a fire should not be considered an unsafe act merel because it is hazardous. If proper precautions are taken, we hav here an illustration of a Forest Service injury avoidance technique If because of lack of know-how the fire boss took his men into situation which later developed into a trap and several wer seriously burned, we have an illustration of an unsafe act. Man actions are normally quite safe, such as smoking, for example However, smoking in an oil refinery or an explosives plant coul be the means of blowing you to Kingdom Come!

An unsafe act domino stands in our way every time an acciden occurs and it is evident that there was a reasonable and les hazardous way that could have been followed. If the hazard re mains despite our best efforts to eliminate it and the job has t be done, then we train, supervise, demonstrate, inspect, and other wise use all the safety gadgetry at our command to sell injur avoidance. Sometimes this domino isn't removed because of hast fatigue, or just downright disregard for common sense. Usuall however, our people commit unsafe acts and take chances becaus they don't know. The slogan on the fire tool decal "Be safe—do right" could just as well read "Do it right and be safe."

An analysis of Forest Service accidents for 1954 reveals th over half of our injuries were a result of not knowing how t avoid injury while performing a hazardous or semihazardous jo The reason may have been a physical defect such as poor visio or hearing; it may have been mental, such as an inclination take a chance, or, as is too often the case of our seasonal employe lack of experience and understanding of the job.

Each one of us can think back on our own Forest Servi experience. I believe you will agree that most, if not all, of o serious and fatal injuries can be eliminated when we determi to plan for safety and then insist on systematic training in t actual performance of safe work practices. Nonroutine work su as we do in the Forest Service can be performed safely if supe vision will insist upon a high degree of technical know-how, a then follow through to see that we are practicing that which know. Let's rid the Region of all "Dangerous Dominoes"!

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

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VOL. 17 APRIL 1956 No. 2

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 17 Number 2

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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Forest Service, Washington, D. C.

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CONTENTS

THE IMPORTANCE OF DESIGN IN EQUIPMENT DEVELOPMENT

STEVEN SUCH

Mechanical Engineer, Michigan Forest Fire Experiment Station

The current trend toward complete mechanization has had its influence in forest fire protection as much as it has in any other field. Prior to the time of heavy-equipment application to forest fire control, only limited usage could be made of anything more effective than the simple agricultural tools. In less than a generation we have moved from shovel to bulldozer, and from buckets to large tankers and high-pressure pumps.

Behind the scenes of this mass movement to powerful machinery is the field of equipment development, made up of research, design, and manufacturing, and of continual testing and improvement. All of these are vital factors in any successful development program, and not the least of these is good design. Simply and concisely, the determinants of design are *cost*, *appearance*, *safety*, and *efficiency*. Rarely, if ever, is any one of these items the sole determinant of design. The careful designer will use all of them in guiding his work, with emphasis on an individual item if there is special need.

Americans today are becoming exceedingly cost conscious. This fact is particularly conspicuous in modern industry where the byword is "cost reduction." Automation is nothing more than rapid production with an eye to lower costs. New methods and modern contrivances for manufacturing are directly intended to mass-produce at a minimum cash outlay. The effect of cost consciousness on the designer too is marked He can never forget that anything he designs must match the consumer's ability to pay; if it does not, it will receive a minimum of use. Such thinking is at times hard to justify from a designer's viewpoint, particularly when he is concerned with quality. Nevertheless, every effort must be made to produce the best possible product within the allowable cost bounds.

Appearance, although normally nonfunctional, must influence all design work. A general rule of thumb that any design that looks good is good, is a risky premise on which to work. A safer premise is that an attractive appearance is the basis on which a majority of manufactured articles are sold. The consumer is entitled to expect smooth and harmonious lines blended into a finished product. However, in designing it remains a matter of common sense not to give a disproportionate amount of time to appearance at the sacrifice of the other three items of cost, safety, and efficiency.

What can be said about safety that has not been said before? Seemingly very little. Absolutely nothing is more deserving of attention than any condition that can threaten the life or health of a man. Utmost care and thought must therefore be given at

all times to operational safety factors and devices. It is the designer's duty and moral obligation to keep safety foremost and always in mind. Socially speaking, safety in design is probably the most important single item to be considered.

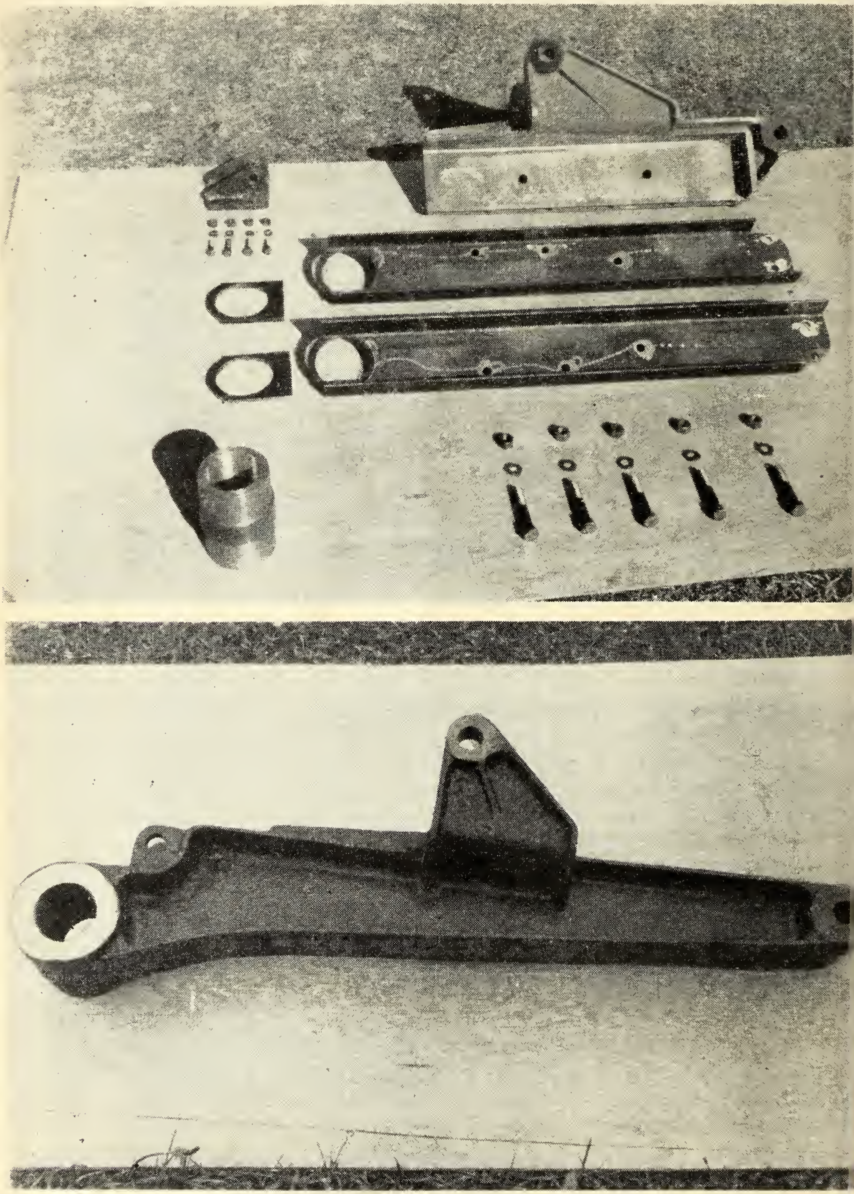

FIGURE 1.—*Top,* These 34 parts were formerly required to make up the bear portion of a hydraulically controlled plow. *Bottom,* This one castin replaces all of the parts in the top photograph. Note smooth lines an minimum machining.

The word "efficiency" in connection with the design of any one unit, as used here, covers (1) operational efficiency, (2) ease of manufacturing, and (3) the combination of multiple functions. Operational efficiency of equipment, for example, is measured by the effort required of the equipment and the excellence of execution of the given job. It is noteworthy that more often than not a high efficiency rating accompanies simplicity of design. The reason for this is beyond the scope of this article.

Where parts are to be manufactured in large quantities, ease of manufacturing is of prime importance. Very often the availability of a machine is determined by its design. In contrast with operational efficiency, ease of manufacturing is measured in terms of hours and dollars. It is therefore extremely important to keep production methods and costs as a control medium in design.

Finally, an alert designer will be constantly aware of the possibilities of combining functions and parts in the interest of efficiency. This means that sound, basic design principles of the most stable nature will be applied, not tinker's innovations.

A practical example of the application of the four determinants of design is found in a casting recently developed in Michigan for use in the production of hydraulically controlled plows. Thirty-four separate pieces were formerly required to do the job the one casting now does alone (fig. 1). The raw-material cost of the casting is approximately four-fifths of the previous cost. Manufacturing time has been reduced to about one-half. Operating efficiency has been increased at least 25 percent. All of the safety devices of the former assembly have been kept. Appearance has been noticeably improved, and at least six separate functions are being performed by the lone casting.

Design has become a significant part of equipment programs in the field of forest fire control because men with much experience in that field know that the best guarantee of strong equipment is good initial design. It is no accident that the steady decrease in acreage lost per fire in Michigan is accompanied by a better and better fleet of fire fighting equipment. Good initial design of equipment will continue to be sought after as one means of fast and effctive control of forest fires.

MARKINGS FOR IDENTIFICATION OF FIRE CONTROL VEHICLES FROM THE AIR

SAMUEL S. COBB
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The rapidly increasing use of aircraft in fire control work during recent years has raised many problems for forestry officials in supervisory positions. The Wyoming Forest District, one of the twenty administrative units of the Pennsylvania Department of Forests and Waters, has been no exception. This district includes, as about one-third of its area, the northern edge of the anthracite coal fields. Once the forest fire hot spot of the State, the section has cooled decidedly over the past 15 years, but because of its high percentage of forested lands, numerous hazards, and flashy fuel types, it is still a fire problem of considerable scope. As a result, the use of aircraft in the district has become greater with each passing year. Planes are used for detection, scouting, and directing ground crews.

One of the major problems has been the identification, by pilot or observer, of ground vehicles of the supervisory personnel of the district. These include those of foresters, fire inspectors, forest rangers, and smokechaser teams. Until the past year, practically all department vehicles were standard model trucks and cars. In the main, fire inspectors and smokechaser teams are assigned ½- and ¾-ton pickup trucks. Rangers use ½-ton pickups and have light dump trucks which are occasionally used for fire work. The foresters drive pickups and standard sedans. Unless these vehicles have special fire fighting rigs such as tanks, live reels, or side racks holding spray tanks, they are indistinguishable from hundreds of similar vehicles when viewed from the air. Many of the fire wardens dispatched to a fire also drive light trucks. Before air to ground radio became available, message-drop tubes were often thrown to crew units distant from the supervisory officer on the fire. In many cases the information dropped never reached the fire boss.

Inspector Robert J. Startzel at the Hazleton Station decided to mark each of his trucks with two white bars about 8 inches wide and at least 4 feet long, parrallel to each other and extending from the front to rear of the truck cab (fig. 1). This marking was soon applied to the fire vehicles throughout the district. When the two aircraft in use were equipped with radios capable of communicating with the tower sets, vehicle mobile units and field portables, the problem of identifying supervisory vehicles became twofold. The primary concern was for the pilot to recognize radio-equipped vehicles to which direct voice contact could be established. The secondary concern was recognition of super-

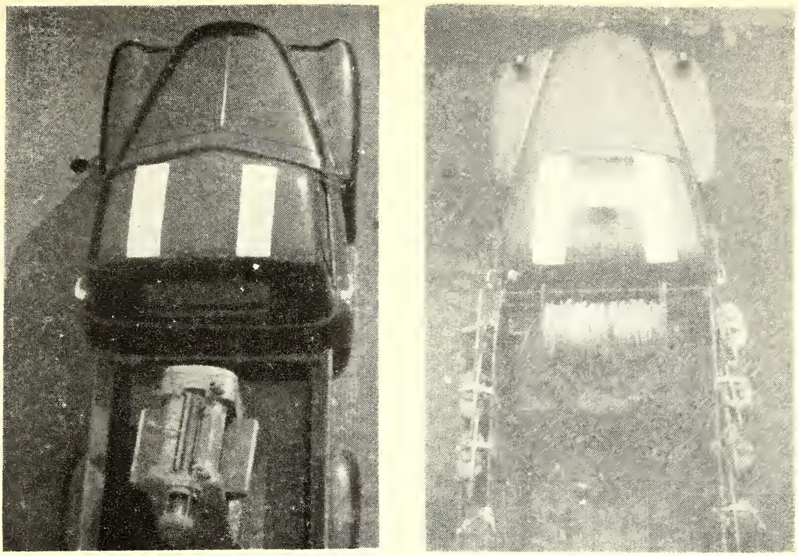

FIGURE 1.—*Left*, Marking originally used to identify all district vehicles. Now used to identify all vehicles not equipped with shortwave radio. *Right*, All district vehicles marked with the crossbar are equipped with shortwave radio.

visory vehicles, not radio equipped, that required use of drop tubes. This latter class was significant in that the vehicles of park and forest rangers in the north end of the district were not radio equipped.

To solve this problem, all radio-equipped vehicles now have a white crossbar painted between the parrallel bars, forming a large H on top of the cab. All district vehicles regardless of their primary work function now carry either the parallel bars or the large H.

During the severe summer fire seasons of 1954 and 1955 and the hazardous spring season of 1955, the pilots of the aircraft and the forestry personnel who often flew with them to direct control activities found these simple markings made it possible for them to identify key vehicles rapidly. It also speeded establishment of contact with the ground forces, especially by radio.

INTEGRATING PREVENTION INTO FIRE CONTROL PLANNING

CRAIG C. CHANDLER
Forester, California Forest and Range Experiment Station[1]

Historically, fire control planning has been concerned prima rily with the job of detecting and extinguishing fires; littl effort has been made to coordinate fire prevention activities witl suppression and presuppression work. But history is a record o change, and now is the time to progress beyond the familia pattern of fire control planning.

Why has prevention been subordinated or excluded fron planning? One reason is that early fire control objectives wer based upon the need to keep the total area burned annually withi a given percentage of the total area protected. Show and Kotol established that the total area burned was closely correlated witl the percentage of fires exceeding 10 acres.[2] They concluded tha the area burned could be reduced to an acceptable amount onl by prompt, effective attack aimed at extinguishing all fires i their initial stages. Under this concept the number of fire start is relatively unimportant—providing all fires are quickly con trolled.

There are two additional reasons why prevention has no been emphasized in fire control planning. First, planning i usually done on actuarial principles, that is, plans are based o past experience. Therefore, in the planning analyses fire occur rence is considered either as a constant or as having a constan trend.[3] Second, transportation and communication facilities hav only recently advanced to the point where prevention and sup pression activities could reasonably be undertaken by the sam personnel during the fire season.

As a consequence, neither the official Forest Service fir control policy (10:00 a. m. control) nor Hornby's principles o fire control planning[4] provide for fire prevention as an inte grated fire control activity.

This is not to say that fire prevention has been ignored o ineffective. Far from it; the national forests in California had 1 percent less man-caused fires per thousand acres in 1950-54 tha

[1]Maintained at Berkeley, Calif., by the Forest Service, U. S. Departme of Agriculture, in cooperation with the University of California.

[2]SHOW, S. B., and KOTOK, E. I. THE DETERMINATION OF HOUR CONTR FOR ADEQUATE FIRE PROTECTION IN THE MAJOR COVER TYPES OF THE CALIFORN PINE REGION. U. S. Dept. Agr. Tech. Bul. 209, 46 pp., illus. 1930.

[3]HORNBY, L. G. FIRE CONTROL PLANNING IN THE NORTHERN ROCK MOUNTAIN REGION. North. Rocky Mtn. Forest and Range Expt. Sta. Pro Rpt. 1, 179 pp., illus. 1936.

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in 1930-34, and 25 percent less area was burned per thousand acres by man-caused fires. During the same period, the *percentage* of fires exceeding 10 acres remained almost constant, while the *number* of class C fires decreased in approximately the same proportion as the total number of fires. From the record it would appear that fire prevention efforts have been as effective as, if not more effective than, increased presuppression and suppression activities in reducing the area burned on the national forests of California. A stepped-up prevention program which would bring about a further decrease in the number of fires started should pay off equally well in reducing the area burned and the consequent damage to natural resources.

To insure that fire prevention plays its most productive role, it must be integrated with the planning and normal operation of the fire control team. Stathem[5] summed up this reasoning in the phrase "A prefire rather than a presuppression organization." To meet the requirements of a prefire organization, principles of fire control planning should be developed which recognize the prevention job as being basic to successful fire control. Once fire control agencies are organized for prevention, they may achieve results far beyond any established goals.

Organizing around fire prevention need not sacrifice the tested standards of initial attack time and strength. Actually some California national forests as well as some State and county units are modifying fire control plans to emphasize prevention. Many standby fire suppression crews have been converted to roving prevention-firemen. They perform prevention jobs while maintaining the same, or improved, standards of initial attack. However, to achieve maximum benefits from a reorganized fire control plan, it will be necessary to do more than merely shift functional responsibilities from one group to another. If fire prevention is to be integrated into fire control planning, a major reevaluation of planning methods is needed.

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[5]STATHEM, P. A "PREFIRE" RATHER THAN A "PRESUPPRESSION" ORGANIZATION. Fire Control Notes 15 (4): 32-37. 1954.

DEN TREE FIRES IN MISSOURI

Osal B. Capps
District Forester, Missouri Conservation Commission

Smoking squirrels out of den trees is an old Ozark custom. Hill people, in general, see nothing wrong with this method of securing "meat for the table" until they realize that more than a game law violation is involved. Some see fire burn their property; others see damage to someone else's property; some realize that many squirrels either burn in the blazing dens or escape. Then, too, the news spreads quickly when someone is convicted in court for causing forest fires.

Fires caused by burning den trees occur more often near population centers and are usually started by urban people who were born and reared in rural areas. Methods used to smoke out squirrels include placing a lighted railroad fusee, igniting dry leaves, or setting fire to gasoline in the base of a hollow tree.

Den tree fires are more of a nuisance to fire control personnel from an acreage-burned viewpoint than a serious threat. They are potentially dangerous, however, in areas where tower coverage is poor. State organizations interested in hunter-landowner relationships also must consider the "No Hunting" signs that are often posted on private land after this type of fire has aroused the anger of the owner toward hunters in general.

The Gasconade District of the Forestry Division, Missouri Conservation Commission, comprises almost 2 million acres of privately owned land. The district is about 66 percent forested and Fort Leonard Wood, Rolla, and several smaller towns are included in its area. Hunters from St. Louis, Jefferson City, and, to a much lesser degree, Kansas City, hunt in the district. Den tree fires were given little consideration until the serious drought years of 1952, 1953, and 1954. In normal years many squirrels are probably smoked out of den trees without the trees catching fire, or, if the trees do burn, without starting active forest fires. During the drought years practically all smoking-out attempts started fires in den trees and these in turn caused active forest fires.

Plans were made in late 1952 to investigate all fires more thoroughly in an effort to separate den tree fires from debris burning fires. Fire prevention activities, including law enforcement, were pointed at den tree fires. Newspaper and radio publicity was given to the number of fires, the damage caused, and the penalties imposed on persons convicted in court for starting such fires. An "Every Sportsman a Fire-fighter" project was highly publicized on a statewide basis to educate the sportsman and to enlist his help in preventing and suppressing fires.

On the Gasconade District in 1953, 70 fires (17 percent of all fires) were definitely started by hunters attempting to smoke squirrels out of den trees. These fires burned 457 acres and accounted for 9.5 percent of all acreage burned. All of these fires

were investigated to determine where and how they started. Evidence, such as empty shotgun shells near the den tree, was sought and an attempt was made to find out who was hunting in the area at the time each fire started. Such facts are difficult to determine because several hours may elapse before the smoldering fire builds up enough to be seen from towers or aircraft.

As a result seven individuals were convicted in court for "molesting den trees by setting fire to trees" or for "negligently causing woods to burn by setting fire to trees." No cases were lost and fines ranged from $1 and court costs to $50 and costs. Court costs ran about $8.50. The average fine was $25.14. Where evidence insufficient to prosecute was secured, persons who had started fires were contacted and warned.

On the Gasconade District in 1954, 47 fires that started from burning den trees burned 155 acres. This was 16 percent of all fires and 4.9 percent of all acreage burned. Six persons were convicted in court for this type of fire law violation. The average fine was $8.50 and court costs again ran about $8.50 per conviction. One man was sentenced to 90 days in jail with the sentence stayed upon good behavior.

Den tree fires will continue to be a nuisance on this district for several years and will be particularly troublesome in drought years. This type of fire will have to be expected and planned for at all times but should decrease in occurrence in proportion to the effort spent in educational activities and law enforcement. Rural residents who smoke out squirrels in normal years become aware of the danger in drought years and are much more careful than their city cousins who frequently have no interest other than "getting meat for the table" or a lot of squirrels to brag about when they go home.

The city man who wants a place to hunt in the future should take heed—the farmer will not tolerate hunters who damage his property. The small fire, while only a nuisance to fire control personnel, may damage some of the best trees a farmer owns. Good sized trees are frequently killed by late spring and early fall fires. Many city hunters will get blamed and penalized for every indifferent hunter who smokes out a squirrel.

SPRAY PLANE CHECKS FIRE

DIVISION OF FIRE CONTROL
Region 6, U. S. Forest Service

Through the years there have been a number of methods in which aircraft have water bombed or applied water to ground fires. As far as we know, the spray-plane method of application described herein is a "first." Two important points need to be understood in connection with the operation: pilot skill, and fuel type.

Pilot Skill:—Crop-dusting spray pilots are skilled pilots. They know their planes and just what can be expected of them. They understand low-level downdrafts and cross winds. No other pilot spends as many hours flying at treetop heights.

Fuel Type:—The fuel type in this fire was cheatgrass. Cheatgrass is a thin-stemmed annual now present to a greater or lesser extent in all the western States except Arizona and New Mexico. When cured, cheatgrass is very flammable. Cheatgrass fires, especially when occurring on steep slopes or when wind driven, are fast spreading. Except for their fast spread, they are are easy to control. Because of the fineness of the stems, cheatgrass fires frequently go out by themselves in the late evening with the rising of the humidity. A very minor amount of spray will bring about control.

During the winter of 1955 the Wenatchee Air Service of Wenatchee, Wash., suggested to Fire Staff Officer Bob Beeman of the Wenatchee National Forest, that a spray plane might be of value in checking the head of a fast-spreading fire in fuels of the type described. Beeman agreed.

On July 23 a dry lightning storm set a fire on the slope of the Wenatchee River canyon near Cashmere, Wash. The fuel type was cheatgrass with scattered sagebrush. The slope was steep. Here was the chance for a test. The plane used was a 135 horsepower super cub equipped with a 100-gallon tank. The plane had, mounted on its wings, twelve 1/4-inch nozzles, six to the side, with a shut-off control from the cockpit.

Pilot Carey made 2 runs across the head of the fire, flying with 1 wingtip at the fire's edge, 10 to 15 feet above the ground. The water spread was approximately 33 feet, the air resistance breaking the water up into a fine spray. The runs were made on the uphill side of the fire on the wind side. Water discharge was 1-1/2 gallons per second and the plane carried enough water for 60 seconds of application. One-quarter mile of fire front was covered at each run.

This trial proved the effectiveness of the spray in checking the head of the fire and gave the ground crew time to control the flanks without difficulty. The fire was controlled at 55 acres.

In reporting this experiment, Supervisor Blair said, "On being advised by Pilot Carey that he had flown 10 to 15 feet above the ground, I felt that this distance was too close for safety and the possibilities of the plane being caught in a downdraft were to

great to permit a continuation of this practice. I am, however, of the opinion that the use of spray planes on fires of certain types has possibilities but more thought needs to be put into the risks involved."

The Wenatchee Air Service suggests that a plane of greater horsepower be used, such as a Stearman with a 450-hp. engine and 150-gallon water tank.

Supervisor Blair commented, "On this particular trial no wetting agent was used in the water."

It is not likely that a wetting agent would have been of any advantage. There is no evidence that it increases the extinguishing power of water on an extremely fine fuel such as cheatgrass. Its value is in deep-seated fuels where penetration is desirable. However, a fire retardant certainly may have possibilities in fires such as this. When a retardant is used it makes no difference if the fine spray does dry out in advance of the fire reaching the line. The salt deposits on the fine fuel will still stop the fire under many situations.

A progress report on Operation Firestop states: "It appears that chemical fire lines may be put in by aerial application." A Sikorsky S-55 helicopter, as was used in the California tests, might well be the answer. Military cooperation, however, would be necessary.

In the fall of 1947 a wild burning prairie fire spread over 380,000 acres of South Dakota farm and grass lands in 2 days. Losses were in excess of 2 million dollars. Much of the fire line, in situations like this, could be "laid down" from the air. Canvas tanks, similar to Harodikes, could be made to fit into the larger helicopters; spray booms could be attached. This would cost money, but so does a 2-million-dollar fire.

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CANVAS WATER SHOW

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A big tank truck, with water capacity of 500 to 1,500 gallons or even more, roaring up to a hard-to-hold sector of fireline causes the pulse to quicken. It's like the feeling, akin to jubilation, experienced by an exhausted, hard-pressed line construction crew when a snorting bulldozer comes crashing through the brush. This is help, real help, when it's needed most.

However, big tankers cost money. There are never enough of them. Frequently there aren't any at all. Does this mean that the use of water on holding, control, and mopup need be abandoned? Not necessarily. Here is an opportunity to put in a canvas "show"—provided you have the gear, and you can buy a lot of gear for the cost of one 300-gallon tanker.

Admittedly, tankers give you a maneuverability not possible with a canvas show. In that respect they are superior. If you can't have the best you will have to settle for less, and second best might very well be a canvas show—unless, of course, the available water is such that you can operate a pumper or gravity show. A canvas show need not necessarily be fixed or immobile, as we shall see.

In addition to hose (which might be considered canvas), nozzles, and in many situations pumps, a canvas show layout may utilize any or all of the following gear: Storage tank, gravity sock, relay tank, transporting tanks. This equipment permits a wide range of combinations in various water show setups.

Storage tank.—A new production item manufactured by a Midwest firm is a lightweight, folding, portable 1,000-gallon tank (figs. 1 and 2). The tank is 8 feet 3 inches square and 30 inches

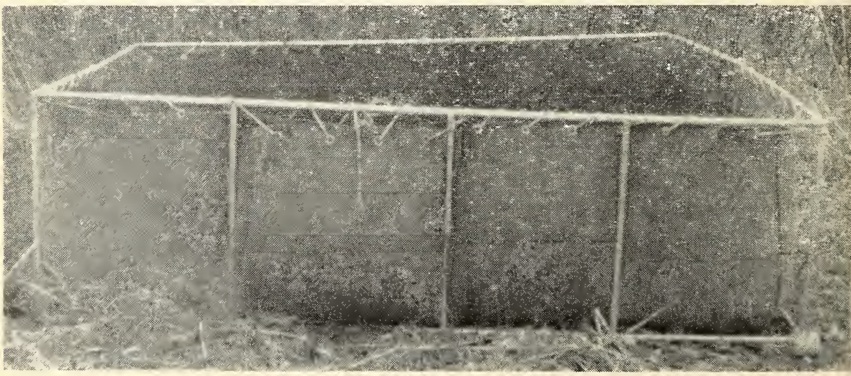


Figure 1.—1,000-gallon storage tank set up for use. The bulge in the second section from the left is the spillway. This section can be unlashed and lowered for quick emptying of the tank. In some tanks, it may be worthwhile to install a collar with a 1½-inch discharge port and cap near the bottom to permit the use of a gravity line instead of a siphon.

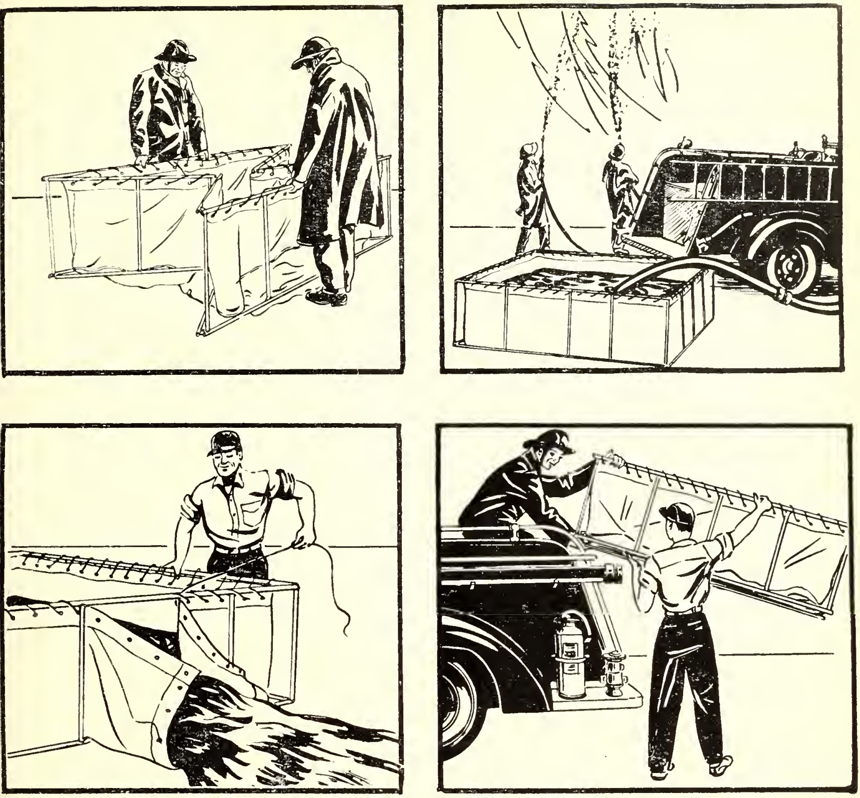


FIGURE 2.—1,000-gallon storage tank.

high; when folded it takes a space 8 feet 3 inches long, 30 inches high, and 10 inches wide. The frame is made of ¾-inch O.D. tubular steel, with welded joints and hinges. Liner material is No. 10 waterproof duck, mildew treated and vermin resistant; bottom and side seams are overlapped and double sewn. The canvas liner has grommeted holes to receive the heavy-duty, long-strand cotton, braided rope lashings. The tank weights 119 pounds and costs $179.50 f. o. b. the factory.

There is some seepage from the tank. The manufacturer states that it amounts to 20-25 gallons in the first 4 hours. Then the seepage gradually diminishes until, after 24 hours, it has practically ceased.

Gravity sock.—Gravity socks or intakes have been in use for years (fig. 3). They are included here, because there are many places where they can be used to fill the 1,000-gallon storage tanks. Tiny rivulets may not sustain a continued pumping operation, but the collection of this water into a storage tank will permit at least intermittent pumping or gravity use. Several intakes to collect ground seepage, such as occurs around springs, may even provide sufficient water for continuous use.

FIGURE 3.—Gravity intake set up for a gravity line. This water supply is sufficient for continuous use without a storage tank. There may be occasions, however, when bringing the water into a tank on a road will provide adequate water for several tank trucks.

Relay tank.—The primary purpose of a relay tank is to boost water to a fire at a higher elevation than could be reached by one pump alone. The usual method is to set up a pump at the water source and pump water into a canvas relay tank some 250-300 feet vertical distance above. At this point, a second pump is used to boost the water up the next leg of the relay, or to the fire, as the case may be. Relay tanks may fit very well into the overall canvas show, to bring water to a tanker filling point, direct to the fire, or to fill the storage tanks for either gravity or pumper operations.

A typical relay tank has a capacity of about 75 gallons. The canvas is treated, mildewproof duck, reinforced at all points of stress.

Transporting tanks.—This term is used to describe the self-supporting pyramidal tank (fig. 4). Since they are completely enclosed, they are ideal for transporting water in pickups, dump or stake trucks, or most any other type of vehicle. Available in 2 sizes, 150- and 300-gallon, they can be used to haul water to a 1,000-gallon storage tank. The 300-gallon size weighs only 24 pounds empty, and 2 of this size will fit easily on a 1½-ton truck. Present cost of the pyramidal tanks is $99 for 300-gallon and $83.50 for 150-gallon size, f. o. b. the eastern factory. They are mildew treated.

The Pacific Northwest region of the Forest Service has many opportunities to use canvas advantageously, especially in connection with fall slash burning. In calendar year 1954, 2½ billion board-feet of timber valued at more than 34 million dollars was

FIGURE 4.—Siphoning water into a pyramidal tank for storage.

cut on the national forests in the region. A volume of cut such as this produces a large and sometimes complex slash disposal problem. The time during which broadcast burning can be done is limited by weather conditions, but unlike the "regular season" fire, there is time for sizeup and advance planning.

Broadcast burning of slash offers an excellent opportunity to study fire behavior, and many of our men are becoming quite adept at recognizing possible trouble spots. More and more water shows are being laid out in advance to handle these expected critical areas.

The region has an average of 1.7 small slipon tankers per ranger district. The pumps on these slipons can be quickly removed and used in the same manner as portable pumpers. In addition there is an average of 1.5 portable pumps per district.

Access to the slash areas is no problem, and many of the cutting areas are on steep ground where gravity systems are a "natural." The 1,000-gallon storage tanks can be quickly moved from one cutting area to another. Any water-carrying vehicle can be used as a nurse tanker to keep them filled, and they in turn are a source for filling the small slipon tankers or for pump or gravity shows. These tanks are a welcome addition to our equipment.

FIRES ARE SMALLER ON THE APALACHICOLA RANGER DISTRICT

H. R. RAUM[1]
District Ranger, Florida National Forests

The total number of fires, most of them caused by lightning, has not substantially decreased since 1939 on the Apalachicola Ranger District. However, a greater percentage of these fires is confined to smaller size classes. A definite increase in percent of Class A and Class B fires is accompanied by a noticeable reduction in percent of Class C fires and a minor reduction in Class D and E (fig. 1). While this chart is not meant to represent regular and steady yearly progress in controlling fires when they are small, it does show the trend toward this goal over the 15-year period 1939-53. Protected national-forest acreage lost to wildfire annually has decreased from one-third of one percent during 1939-43 to one-fifth of one percent during 1949-53.

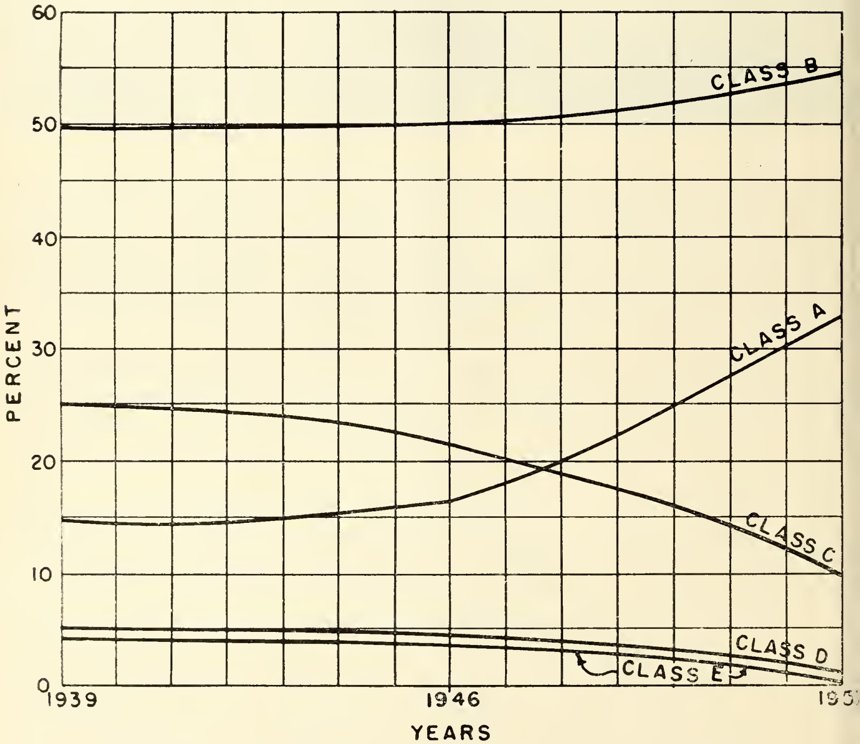


FIGURE 1.—Trend in percent of fires on the Apalachicola Ranger District by size classes, 1939-54.

[1]Now on the Supervisor's staff, North Carolina National Forests, Asheville, N. C.

Several factors have contributed to this trend. The increased ıse of mechanized equipment to replace manpower since the close of the CCC period is probably the most important. The chart ndicates the beginning of the trend to smaller fires at about this same time. The Apalachicola Ranger District is equipped with heavy-duty tractors and plow units of the TD-9 Mathis type transported on 2½-ton tandem-drive trucks. Travel time to fires has been materially reduced by the change from semitrailer units to the present tandem-drive vehicles. The replacement of manually operated plows with hydraulic units and the development and use of tanker equipment has reduced fire control time. These factors have resulted in a corresponding reduction in area burned.

State highway construction in this district, together with construction and improvement of U. S. Forest Service roads, has speeded up control action, especially in the southern part of the district. In some areas travel time has been cut by two-thirds because of improved roads.

A carefully planned prescribed burning program, designed to form patterned barriers against large fires, has played an important role in the task of keeping down the size of wildfires. Prescribed burning was started in 1943 on this district; now about 20 percent of the net burnable acreage is prescribe burned annually.

We are compelled to depend almost entirely upon U. S. Forest Service crews for suppression action. There are no sources from which to obtain large crews of fire fighters within reasonable time limits. The fact that fast spreading fires in flash fuels can start within a few hours after a rain, together with yearlong fire occurrence, requires that we apply all available means of controlling fires while they are small.

INEXPENSIVE ELECTRIC STARTER FOR PORTABLE PUMP ENGINES

MELVIN A. FREYTAG
District Forester, Ohio Division of Forestry

The starting device described here was designed and built by fire control personnel of the Ohio Division of Forestry, New Philadelphia, Ohio, at a cost of $28.43 for materials. It was designed to remedy engine starting difficulties experienced with a new truck-mounted portable pump. This starter has now undergone sufficient testing to assert that it efficiently fulfills its purpose.

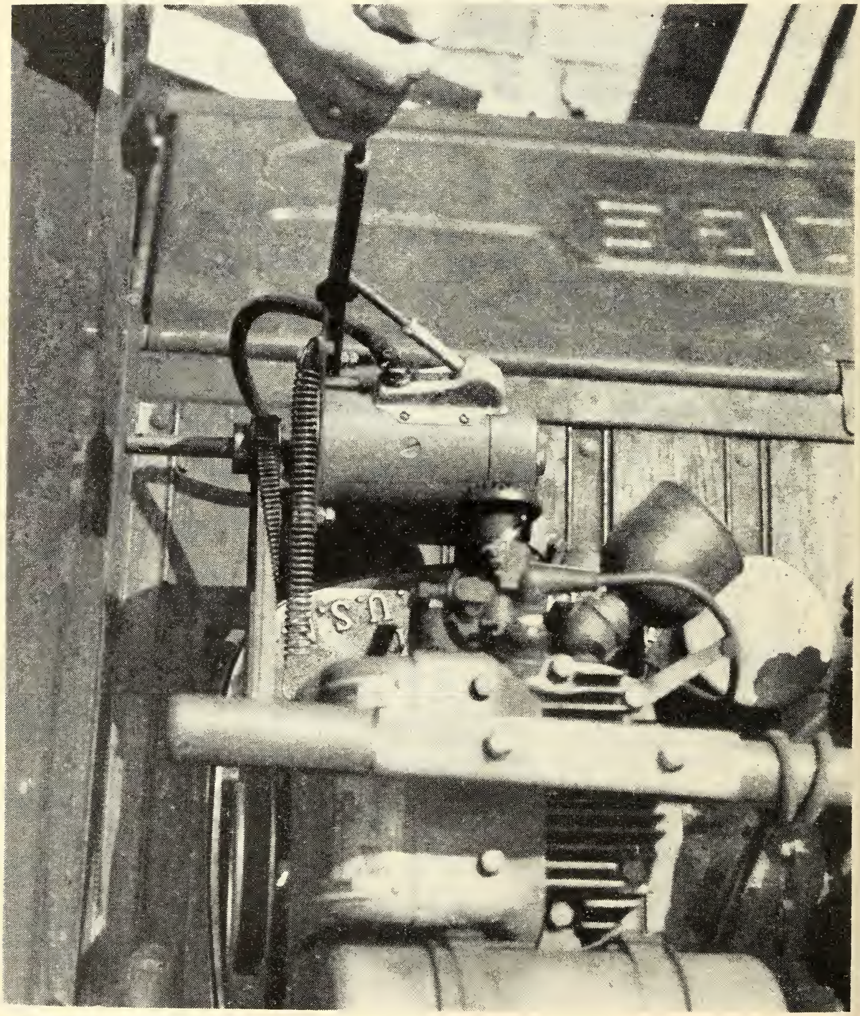


FIGURE 1.—Pulling the starter handle tightens drive belt; moving it toward switch will close contact and start motor.

The principal part is a rebuilt, 6-volt automobile starter motor that is powered through cable connection to the truck storage battery. Power is transmitted by a V-belt from a 2-inch V-pulley on the starter to a 5-inch V-pulley mounted on the pump engine. The starter, which is hinge mounted, is held in a non-operating position by a coil spring. A handle is mounted on the starter swinging it away from the pump motor and so placing tension on the drive belt. Side motion of the handle permits activating the starter at the same time tension is applied (fig 1).

To operate starter, pull handle until sufficient tension is applied on the drive belt to transmit the power. Then, move handle sideways toward switch to close the contact and start motor. When pump engine starts, release tension on starter handle so coil spring can return starter to a forward, nonfunctioning position. Remove drive belt from rotating engine pulley to prevent wear.

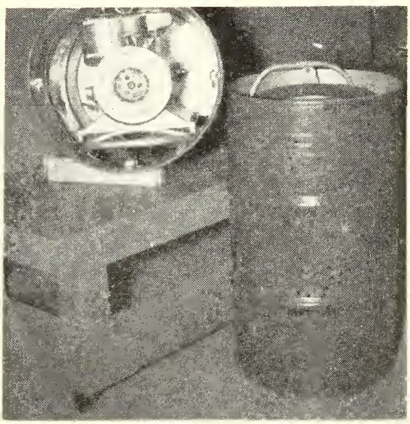
The starter can be detached easily from its base to permit removal of the pump. The pump engine can be started in the field by use of a standby starter rope.

☆ ☆ ☆

Oil Drum for Parachuting Portable Pumper

Parachuting pumper equipment to fire fighting crews in the back country may spell the difference between a fire getting away or being controlled while small. A 35-gallon oil drum container has been used successfully to protect a portable pumper dropped by parachute.

The top of the drum is cut out and the pumper, mounted on a metal pack frame, is bolted by four wing nuts to the inside of the drum near the top. The pumper is suspended approximately 4 inches off the bottom. Four rings are bolted to drum near the top for fastening the parachute. The container is disposable. Total weight of container and pack frame is about 37 pounds, with "Y" pumper, 107 pounds.



When the smaller 38-pound pumper unit is used, in addition to the pumper and metal pack frame, the container holds an accessory kit, 1 gallon of gas, and 500 feet of 1-inch linen hose. The rolls of hose are placed in the bottom of the container; then the pumper is placed in position and bolted in. The gas and accessories are placed on top of hose and the unit is ready. The complete outfit, including container, weighs 156 pounds.—Louis F. [illegible]eyak, *Fire Control Aid, Superior National Forest.*

METAL PACK FRAMES FOR PORTABLE PUMPERS AND POWER SAWS

LOUIS F. DEYAK
Fire Control Aid, Superior National Forest

Pack frames are often necessary for carrying portable pump- ers and power saws. The familiar wooden pack frame served the purpose, but had the disadvantage of excessive weight, joints became loose after limited use, wood became oil soaked, and the frame was hard to construct. A wooden frame sturdy enough to stand the wear was too large and cumbersome.

A metal pack frame with welded joints, which eliminates all of the above disadvantages, can be easily constructed from ½-inch thin wall conduit (fig. 1). It weighs half that of the wooden frame and costs about $12.

These materials are needed:

1 10-foot length of ½-inch thin wall conduit.
6 ¾-inch harness rings.
4 ¾-inch harness buckles.
4 3/16- by 2½-inch stove bolts with wing nuts.
1 4-foot length of ¾-inch leather strapping.
1 14-foot length of condemned 1½-inch linen fire hose.
2 webbed shoulder straps (as used on fire backpack pumps).

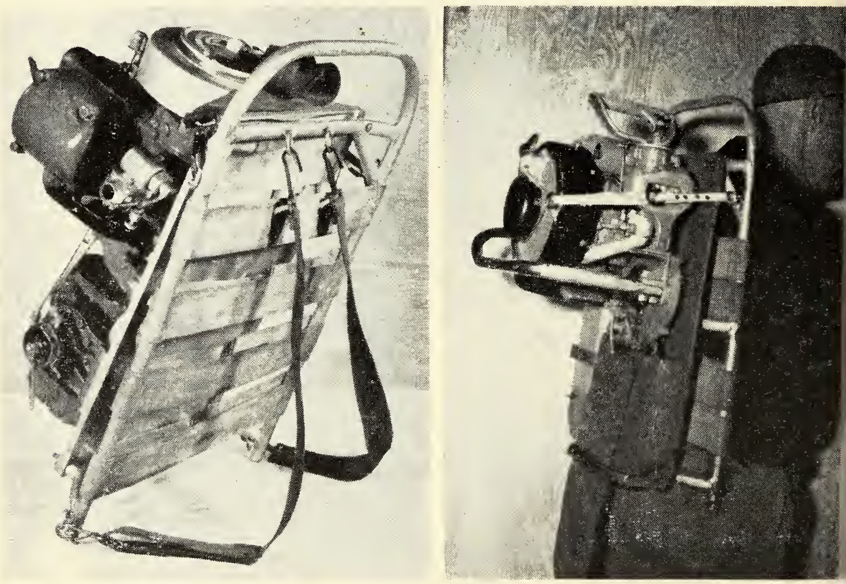


FIGURE 1.—Metal pack frame: *Left,* portable pumper bolted down; *right* power saw in place. The four lengths of 1½-inch linen fire hose are pulled tight by means of ¾-inch harness buckles and leather strapping riveted to the ends.

A portable pumper with accessory kit and suction hose can be mounted as a compact unit weighing 64 pounds on the metal pack frame. The 1-inch suction hose is wrapped around the pumper and tied.

The mounted saw is a complete unit weighing 50 pounds. The accessory box is made as part of the pack frame and contains an extra saw blade, pliers, 6-inch screwdriver, 8-inch adjustable wrench, $\frac{5}{8}$-inch socket wrench, spark plug wrench, one connecting link and rivet assembly, extra spark plugs, a few extra cutters and rakers, quart of oil for oil reservoir, and notebook and pencil. The saw is very easily dismounted from the pack frame by loosening 2 wing nuts which hold the beaver tail in place, loosening the strap which holds the saw to the pack frame, and lifting up.

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Rear-Step Push Button for Enclosed Cab Fire Trucks

Safety is a major concern of every fire chief. Here is one device that has paid dividends in added safety. Push buttons have been installed on nearly all the fire trucks of the Central Rhode Island Firemen's League. The button is within easy reach of the rear-step riders and activates a bell or buzzer in the driver's cab. A code is used to transmit emergency instructions to the driver.

This system of communication, long in use between tillermen and drivers of aerial-ladder trucks, was adopted by the West Greenwich Fire Department after a disastrous incident last year. Working close to the flames of a forest fire, one of the riders on the rear step had the misfortune to have his shirt catch fire. The flames, fanned by wind created by the truck's passage down the road, engulfed the unfortunate fireman. The other rear-step riders shouted to the driver to stop, but they could not be heard. The flaming man was forced to jump from the rear step. He was followed by two fellow firemen who promptly extinguished the flames. However, the burns suffered by this fireman were so serious that he was hospitalized for a long period.

The Hopkin's Hill Fire Department, on learning of the emergency communication installations on the West Greenwich Fire Department trucks, adopted the device for their own trucks. Shortly after rear-step push buttons had been installed, a dramatic proof of their usefulness was enacted.

While answering an alarm at 45 m. p. h. one of the fire trucks lost a tie-rod! A fireman, following in his own automobile, saw the tie-rod fall off. Quickly breasting the rear-step riders, he told them what had happened and to slow the racing fire truck gradually to a halt "so they wouldn't fetch up in a heap!"

Using the buzzer code, the rear-step riders instructed the driver to bring the truck slowly to a halt. Whereupon the driver jumped to the ground, demanding angrily to know what in blazes they thought they were doing! They pointed to the tie-rod being brought up by the fireman in the automobile and suggested it be put back on the truck before going any farther. This rear-step push button for emergency communication is a safety device of wide usefulness.—ANNE C. HOLST, *Cedar Hill Forest Fire Experiment Station, Cedar Hill Fire Department, Cowesett, R. I.*

AIR DELIVERY OF WATER HELPS CONTROL BRUSH AND GRASS FIRES[1]

JOSEPH B. ELY, *Fire Control Officer, Mendocino National Forest* and ARTHUR W. JENSEN, *Forester, Division of Forest Fir Research, California Forest and Range Experiment Statio*

Dropping water or fire-retardant chemicals from low-flyin aircraft can help ground forces control brush and grass fires. Tha such water drops are practicable has been demonstrated by recent series of field trials and calibration tests conducted by th Mendocino National Forest and the California Forest and Rang Experiment Station in cooperation with the Willows Flying Serv ice, the California Division of Forestry, and the Arcadia Equip ment Development Center. As much as 120 gallons of water at time was carried to fires in an airplane normally used for cro dusting and other agricultural purposes. Water dropped throug a single outlet designed by the Willows Flying Service prove effective in quieting hot spots on large fires and in retardin spread of small fires in brush and grass.

Previous studies have established several guidelines for drop ping water from aircraft: (1) The danger to men, equipmen and buildings prohibits the use of missiles or droppable contain ers—in fact, any projectile—in populated areas or as close sup port to fire fighters on the ground. (2) Aircraft must be maneu verable and have a considerable reserve of power. (3) Pilot should be capable of flying close to rough topography and o achieving pinpoint accuracy with safety. (4) Water dropped fre fall reaches the ground and has a significant effect on some fire

In consideration of these guidelines, it was decided to test th adaptability of an agricultural aircraft as an aerial tanker, an to attempt drops of uncontained water on fires.

At the suggestion of the fire control staff of the Mendocin National Forest, the Willows Flying Service adapted a 450-hors power biplane used in agricultural work for trial as an aeri tanker. The spray equipment connected to the 160-gallon tank the fuselage was removed and a single outlet was installed at t base of the tank.

The outlet measures 7 by 18 inches and is constructed of hea sheet metal. The outlet gate is hinged at the front and has rubber gasket to insure watertight seal. At first, when the ga was opened by tripping a simple latch from the cockpit, the su den release of water caused the plane to jump about 100 feet a the pilot to black out temporarily. This difficulty was corrected equipping the outlet gate with a controlling lever which permitt the pilot to open the gate more slowly in all subsequent tests.

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[1]Reprinted in part from "Air Delivery of Water Helps Control Bru and Grass Fires," by Joseph B. Ely and Arthur W. Jensen. U. S. For Serv. Calif. Forest and Range Expt. Sta. Forest Res. Note 99, 12 pp., ill 1955.

Preliminary trials conducted in early August 1955 over flat ground at an airport showed that water could be dropped successfully. In the first trial, 120 gallons of water was dropped from an elevation of 30 feet at an airspeed of 80 miles per hour. The water from this drop covered an area approximately 30 feet wide and 285 feet long. A test fire in grass, 20 feet wide and 600 feet long, required three 120-gallon loads of water and 10 minutes of follow-up work by hand for control.

The next step was to try water drops on actual wildfires. In three trials during August the air tanker proved to be of considerable help to ground forces although in one of these it was apparent that too much was expected of a single plane.

The Mendenhall fire of August 12 covered about 400 acres in grass, brush, and timber; crowning uphill; weather hot, dry, and windy. The plane supported initial action forces on flank in grass and mixed oak with 240 gallons of water in 2 loads. Support was effective where used, but there was too much line for one plane to handle.

With the weather hot, dry, and windy, the August 13 Mendenhall fire of 700 acres was temporarily controlled at head and one flank. Lower end of fire, burning downhill in chamise, became too hot to handle by direct attack and threatened to outflank existing control lines. The plane, refilling repeatedly at nearby airport, delivered 600 gallons in 5 loads to 15 chains of lower end of fire. Fire cooled down enough so that attack forces were able to build control line along fire edge. Fire fighters stated they could not employ direct attack until flames were suppressed by plane. In this trial, 120 gallons applied in 6 passes was not nearly so effective as when applied in 3 passes.

The John David place fire on August 15 was in bottom of narrow box canyon with adjacent slopes rising 2,000 feet on one side and 5,000 feet on the other. Cover consisted of medium-density mixed brush with grass. Head of fire controlled but hot-burning corner threatened to outflank control line. Corner too hot for direct attack and moving too fast for indirect attack. Refilling at nearby airport, plane delivered 480 gallons in 4 loads to hot corner by flying up and down the canyon. Water cooled down hot corner enough to allow men to complete their control line close to fire edge. District ranger and others reported air tanker instrumental in control.

On initial attack the loaded plane was dispatched from its Willows base immediately after ground forces were started to fire. At the same time, aviation gasoline and a water tanker were sent to the airport nearest the fire. A reconnaissance plane, in communication with ground forces and the "refill" airport, correlated the ground and air activities. In the future the company plans to fly a maintenance mechanic to the airport to refuel and load the air tanker, do maintenance work as necessary, and prevent damage to the plane by well-intentioned but inexperienced personnel during the loading operations.

It was apparent that air delivery of water made this aircraft a practical fire fighting tool, but quantitative information was

needed to improve tactical methods for water delivery. Accordingly, a limited series of tests was conducted to obtain the following information: (1) Effect of plane height, plane speed, and wind velocity and direction on amount and distribution of water received on the ground. (2) Amount of water loss to be expected during summer fire weather. (3) Effect on amount and distribution of dropping part of total load in each of several runs (multiple passes) with pilot aiming for same spot each time. (4) Practicability of dropping a sodium-calcium borate fire-retardant. (5) Amount of penetration of water and retardant into brush cover.

Although this aircraft can carry a maximum of 160 gallons of water, nominal full-load tests were made with 125 gallons of water or 100 gallons of retardant. At elevations normally experienced on the Mendocino National Forest this is the maximum safe load.

During the tests wind velocity varied from calm to 8 miles per hour, air temperature from 80° to 110° F., and relative humidity from 6 to 19 percent.

The patterns of distribution from these tests were roughly oval, from 4 to 7 times longer than wide. When the full load was released in one pass the greatest concentration of water was obtained when the airplane was flying at low speed and low elevation into the wind. Both higher speed and greater elevation increased the total length of pattern but gave lower concentration.

About 75 percent of the water reached the ground in measurable quantities in the low-altitude, low-speed, headwind tests; about 65 percent in the higher altitude, cross wind tests. At top speed and low elevation, about 70 percent of the water released reached the ground. Only 20 to 30 percent of the water reaching the ground was in concentrations of 1 gallon or more per 100 square feet. Apparently, wind direction and velocity are the most important factors affecting percent of water reaching the ground in a useful pattern.

Relatively high concentration was obtained when a 40-gallon load was dropped in one pass as compared with a 125-gallon load dropped in multiple passes. In making more than one pass with a capacity load, the manually operated outlet gate was only partially opened for each pass because it could not be closed against a full-stream discharge. As a result, only about half of the water reached the ground in measurable quantity. More rapid release of water should result in greater concentrations for all sizes of loads.

In medium and light brush there was no significant difference between the amounts of water received at the crown and on the ground. In heavy brush, however, there was considerable variation—from 20 to 90 percent as much water reaching the ground as was received at crown level.

Results from the retardant tests were similar to those obtained with plain water. However, the heavy sodium-calcium borate suspension, weighing 10 pounds per gallon, did not disperse as readily as water and had a smaller distribution pattern wit

particularly heavy concentration in the center. Penetration into heavy brush was more uniform than with water; 45 to 60 percent of the amount received at the crown level reached the ground. The standing brush was well coated with retardant.

Conclusions and Recommendations

These limited tests have shown that water or chemical dropped free-fall from small airplanes can have significant effect on small grass and brush fires, or on some parts of large ones. To obtain the greatest concentration of liquid on the ground, the airplane should fly as low and as slowly as conditions permit and as nearly into the wind as possible. The more rapidly water is released, the greater the concentration will be. Increasing the altitude or air speed or dropping in a crosswind will give greater area coverage but will reduce concentration.

As with all specialized tools, the aircraft used for aerial tankers must be in top mechanical condition. Also, pilots must be experienced both in flying under mountain conditions and in low-level air drops. Pilots are cautioned to watch for sudden jumps when releasing large amounts of water. They should avoid a tail-down plane attitude when dropping from low heights to minimize effects of slipstream on the water.

One aerial tanker has been of significant assistance to ground crews on fires. Indications are that several planes used in quick succession will not only be more efficient but may be able to hold temporarily short pieces of hot fire line. It is not necessary to evacuate the target area as these uncontained water drops are not dangerous to personnel.

Considerable work still needs to be done before the aerial tanker can become a common fire fighting tool. The optimum speed, altitude, direction of flight, and method of releasing the water or chemical for each tactical situation need to be determined. Information is needed on the amount of water or chemical required to affect fires under different fuel and burning conditions. More test drops should be made under a greater variety of weather and fuel conditions, particularly at wind velocities greater than those encountered in these tests. A means of closing the outlet gate against a full stream of water is needed to permit higher concentrations of water than are now possible in multiple-pass drops. Ground-to-air communication should be improved for better tactical use.

PACKBOARD HOSE LAY

FIRE CONTROL PERSONNEL
Cajon Ranger District, San Bernardino National Forest

During the past two fire seasons, the Cajon District of th San Bernardino National Forest has developed a quick an efficient system for making a hose lay, by use of hose packed o a packboard. Where tankers cannot get close to a fire, a 600- t 800-foot hose lay can be run and water delivered at the nozzle in 2 minutes.

The pack consists of 100 feet of 1-inch cotton jacket or 20 feet of 1-inch nylon jacket hose, packed on a 10- by 21-inch pack board. The hose is tied to the packboard in such a manner tha it will come off easily and not become tangled (fig. 1).

Using 100 feet of the cotton jacket hose, the packing is starte with the male connection or nozzle first (fig. 1, *B*). The hose i then folded lengthwise on the packboard until there are 7 fold (hose overlaps the ends of the packboard about 3 to 4 inches) This layer is then tied tight in 3 places, using 2 strands of cotto string at each place. Ordinary light cotton string is used becaus it will break easily when the hose is run out.

After the first layer is securely tied, the second layer is place on top of it with seven folds and the ends even with the bottor layer. This layer is then tied tight to the packboard with mor string (fig. 1, *C*). The last layer has six folds, ending with th female connection on the side and near the bottom of the pac (fig. 1, *D*). This last layer is also tied to the packboard wit string. To insure against the pack coming apart before it is read to use, the whole pack is tied with two straps that are fastene to the packboard (fig. 1, *A*).

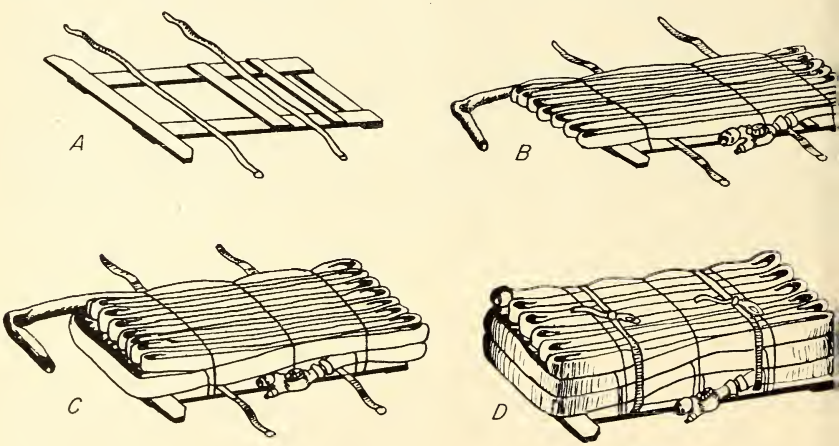

FIGURE 1.—*A*, Packboard ready, with straps, for loading hose; *B*, *C*, *1* layers of hose properly placed and tied.

If 200 feet of nylon jacket hose is used, the procedure is the same, except the first layer of hose has 14 folds. The second layer has 13 folds, and the third layer 12.

One siamese hose lay, of which many variations can be used to meet varying conditions, requires a 5-man crew with at least 1,000 feet of hose. Initial hose lay consists of 200 feet of 1½-inch cotton jacket, rubber-lined hose, 800 feet of 1-inch nylon jacket, rubber-lined hose in 4 packs, a 1½- to 1-inch reducer siamese shut-off valve, a 1-inch siamese shut-off valve, and 2 nozzles.

Foreman carries packboard with 200 feet of 1-inch hose and nozzle, and pulls 1½-inch hose with reducer siamese out 200 feet from tanker. To the siamese he attaches the hose packed by No. 1 nozzleman who is following 20 feet behind him. Foreman, No. 2 nozzleman, and utilityman proceed 400 feet out to position for 1-inch siamese. Utilityman hooks foreman's hose to one side of siamese and No. 2 nozzleman's hose to other side. Foreman starts flanking fire in one direction, No. 2 nozzleman in the opposite direction. When No. 1 nozzleman arrives with more hose, the foreman gives him nozzle and is then free to direct action on fire.

No. 1 nozzleman, who has been 20 feet behind foreman helping pull 1½-inch hose, proceeds 200 feet after his hose is hooked up to siamese. He then hooks the utilityman's hose to the hose lay, and returns to siamese to await signal from utilityman to turn on water. After turning on water, he takes pack with 200 feet of hose, which has been brought to the first siamese by the truck operator, and proceeds out hose line to relieve foreman of nozzle. The hose he is carrying is extra.

Utilityman takes packboard with 200 feet of hose and the 1-inch siamese. He follows 20 to 30 feet behind No. 1 nozzleman and helps pull 1½-inch hose. He stays behind No. 1 nozzleman until 200 feet beyond first siamese. Here his hose is hooked into hose lay, and he follows foreman 200 feet to where he attaches second siamese. He then signals No. 1 nozzleman for water to this point. After this, he hooks foreman's hose to one side of siamese and No. 2 nozzleman's to the other. He then controls the water from this point or can go after tools and more hose.

No. 2 nozzleman, carrying packboard with 200 feet of hose and nozzle, follows 20 to 30 feet behind utilityman and helps pull 1½-inch hose. When he reaches second siamese his hose is hooked up to one side and he proceeds 200 feet around fire.

Tank truck operator checks truck and starts pump to charge 1½-inch line to first siamese. He takes shovel and packboard with 200 feet of hose to the siamese and then stands by where he can control the pump or the siamese in case of broken hose. He also acts as utilityman in relaying hose or tools.

FIRE EXTINGUISHERS, THEIR TYPES AND US
V. VAPORIZING LIQUID

A. B. Everts
Equipment Engineer, Division of Fire Control, Region 6, U. S. Forest Service

Vaporizing liquid is perhaps the best known, after water, c the extinguishing agents. This type of extinguisher[1] is ofte referred to as a "Pyrene," which is the name of only one of th many companies that manufacture this particular type of pum gun. The layman thinks of vaporizing liquid as carbon tetra chloride (referred to as CTC), but this is not the only one c even the best. And therein lies the renewed interest in vaporizin liquid. Many compounds, with long names, are still undergoin tests and the best one probably has not yet found its way int general use.

Vaporizing liquid, as the name indicates, is a liquid that whe directed on a fire quickly vaporizes into gas. The gas smothe the fire. An intense fire will bring about quicker vaporizatio than a smoldering fire. Since a smothering agent will not cool th burning fuel, vaporizing liquid is not as effective on Class A fires as a quenching and cooling agent; that is, water or foan However, vaporizing liquid (VL) will, and has, extinguished man small fires of this type. Success depends on the type of fire. Pape burning in a metal wastebasket, for instance, can be quickl snuffed out by VL (as by CO_2), but fires in overstuffed furnitur wood, or other deep-seated fires are not that easily handled. R ignition will quickly follow. VL is rated as a Class B and Class extinguisher, but because of its knockdown of small Class A fire it is often thought of as a universal type of extinguisher.

In a series of test fires, 8 pounds of pine needles making layer about 2 inches thick in a 4- by 4-foot frame were used. Th fire was extinguished only once by ½ quart of CTC; in oth attempts, reignition occurred immediately. This is why timbe fallers using power saws on national-forest timber sales in som regions are required to carry a shovel. The small extinguish may handle a small gasoline fire, but when the fire involves fore fuels, a shovel is needed to build line or throw dirt.

How to use the extinguisher.—On Class A fires, direct the V stream at the base of the flames. On Class B fires (flammab liquids) best results are obtained when the discharge from th extinguisher is played against the inside of the wall of the co tainer, just above the burning surface. The stream should not b

[1]For more information on classes of fires and types of extinguishers se *Fire Extinguishers, Their Types and Use. I. Carbon Dioxide Extinguishe II. The Dry Chemical Extinguishers, III. Water-type Extinguishers,* a *IV. Foam Extinguishers*, by A. B. Everts. Fire Control Notes 15 (4): 1- illus. 1954; 16 (1): 9-12, illus. 1955; 16 (2): 24-26, illus. 1955; 17 (1 12-13, illus. 1956.

directed into the burning liquid. Where possible, the operator should walk around the fire while directing the stream so as to get maximum coverage during the discharge period.

On Class C fires, especially fires in live electric motors, VL is an excellent extinguishing agent. The reason is that the stream can be directed into the small openings of the motor housing easier than is possible with CO_2 or dry chemical. There is no danger from electric shock and no residue is left on the motor.

Types of VL extinguishers.—There are a number of types and sizes of VL extinguishers:

1. The hand pump type, which has ben in use for many years, is manufactured in a number of sizes: 1-, 1¼-, 1½-, and 2-quart, and 1-, 2-, and 3-gallon.

2. Stored pressure type (figs. 1 and 2). All the major manufacturers now make VL extinguishers that can be pressurized with air, CO_2, or nitrogen. This type has a gage by which the pressure can be easily checked to insure that the extinguisher is properly charged. Internal pressure is usually 150 pounds. Most of these are 1-quart size.

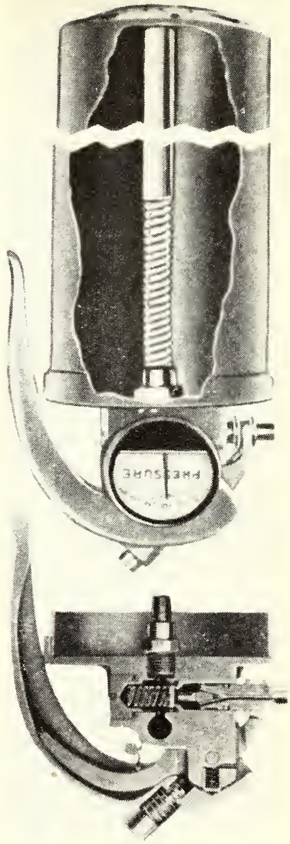

FIGURE 1.—Cutaway of a stored pressure VL extinguisher. The inside siphon tube is flexible so that more of the liquid can be discharged when the extinguisher is in a near horizontal position.

These extinguishers can be charged directly from a service station air chuck, the same as is used to inflate tires. All service stations, however, do not carry 150 pounds' pressure on their compressors. CO_2 is favored as a pressure medium. However, if CO_2 is used in cold climates, the pressure decreases as cold weather sets in. The pressure can be brought up to the recommended 150 pounds, but as spring and summer come around again, some of the pressure should be drained off. This can be done by turning the extinguisher upside down and releasing some of the CO_2 gas.

3. "One-shot" disposable extinguishers. These contain 16 ounces of CTC and are pressurized with CO_2. A small copper tube runs to the bottom of the can. To put the extinguisher into use, a ring is pulled to break the copper tube where it is crimped at the top of the can. These extinguishers are comparatively cheap.

4. The little 8-ounce pressurized extinguisher that is carried by many timber fallers for use on power saw fires. The agent in this extinguisher is chlorobromomethane (CBM).

FIGURE 2.—Extinguishers 1, 3, and 4 are all 1-quart VL stored pressur extinguishers. All have pressure gages. Extinguisher 3 can be pressur ized in the field with the large CO_2 cartridge shown above it. Extin guisher 2 is a 1⅜-quart water type of extinguisher known as "aircraf type," and designed for Class A fires in cabins of airplanes. It is pres surized with a small CO_2 cartridge which is inserted in the handle an ruptured (by turning) when put into use. The four small objects, uppe left, are small capacity fog nozzles used on these extinguishers in a experiment to see whether fog is more effective than a straight strea

While all these extinguishers were designed for using vapor izing liquids, there is no reason why they cannot be used fo expelling any kind of liquid. A fog tip will give spread, if suc is desired. The aircraft type, using plain water, is good pro tection for Class A hazards in the home. A fire retardant can als be used. There is a wide price range depending on the type an size.

Types of vaporizing liquid.—There are a number of vapor izing liquids used in fire extinguishers:

1. Carbon tetrachloride is the best known and the cheapes It is treated with components for depressing the freezing poin to 50° F. below zero.

2. Chlorobromomethane (CBM), aslo called bromochloro methane, is a German discovery. It is claimed that 1 pound o CBM is equal to 2 pounds of CTC. It will not freeze at tempera tures above 100° F. below zero. CBM is more expensive than CTC

3. Azeotropic chloromethane (CM-7) is still another com pound recently developed which, it is claimed, will not produc toxic gas as the result of application to a fire.

4. Bromotrifluoromethane has shown remarkable extinguish ing ability in tests conducted by the Navy.

There are others. Some of them are used in mixtures wit methal bromide and with ethyl bromide. Research objective i to find a low freezing point liquid, with the greatest fire ex tinguishing ability, without a hazardous release of toxic gas.

WARNING: Too much stress cannot be placed on extreme are in the use of VL fire extinguishers in enclosed places. This s especially true of CTC. It should never be used as a cleaning olvent. Take heed to Robert Palmer, Industrial Hygiene Enineer, Oregon State Accident Commission, who reported: "No ntelligent person would think of running his automobile in a arage with the doors closed, yet carbon tetrachloride is *four imes as poisonous as carbon monoxide.* It is nearly half as danerous as deadly hydrogen cyanide. Phosgene gas, produced when arbon tetrachloride comes in contact with any hot surface, is *en times as toxic as hydrogen cyanide.* Three-fourths of a teapoonful of carbon tetrachloride, evaporated and equally disributed in the air of a room 10 feet long, 10 feet wide and 10 eet high, will produce a toxic concentration. Just three drops f carbon tetrachloride, sprayed onto a fire and converted into hosgene will affect the health of a person in the same room . . . .

"There are many more cases of minor to severe carbon tetrahloride poisoning on record, and no one knows how many uneported cases because the symptoms of carbon tetrachloride oisoning are often just like kidney or liver ailments of an rganic nature. Also the effects are often slight and temporary. 'hat is, they seem to be temporary, but the damage done by arbon tetrachloride is permanent and the effects may not show p for months or even years after exposure and the unfortunate ictim may have forgotten that he was ever exposed at all."

If you are depending on CTC for home protection for an oil urnance or stove, or for an electric range, be sure you, your vife, all members of your family are aware of this hazard. It s probably safer to change to CO_2 or dry chemical.

Maintenance.—The principal point in connection with mainenance of CTC extinguishers is to use a good grade of liquid, ot the type that is used for cleaning. In inspections, pour the iquid into a clean container. If a gray scum is detected it is robable that the liquid is of inferior quality and that water is resent. Even a minute amount of water will form hydrochloric cid which will cause corrosion.

Always make sure that the discharge port or nozzle is open nd that the pump operates correctly. In the pressurized type, heck the gage to be sure the pressure is right.

The manufacturers say "never use water in the extinguisher." Vhat they really mean is that water should not be used to test he extinguisher because of the danger, as stated above, of formng hydrochloric acid when the extinguisher is filled with CTC gain. There is no reason why these extinguishers cannot be ised as "water type" extinguishers, especially with retardants nd a noncorrosive wetting agent.

Summary.—(a) The VL type extinguisher is for flammable iquid fires and for fire in electrical apparatus. It is also effective n some types of small fires in paper, textiles, wood, or similar lebris. (b) It is by far the most dangerous (if vapors are reathed) of all the five common types of extinguishers. Anyne who might use the extinguisher should be warned of the

hazard. CTC in contact with flame forms gases that are danger ously toxic. All other chemicals are reported to be toxic to som degree. (c) Range of projection varies according to pressur medium, type of extinguisher, and whether the liquid is dis charged in a spray or straight stream (20-30 feet in some straigh stream types). (d) Costs cover a wide range, depending on typ and size. (e) Maintenance requires an annual check and use of good grade liquid.

Grenades and spray devices.—In addition to the extinguisher already described, there are a number of grenades meant to b thrown at a fire. There are also wall and ceiling spray devices some of them pressurized with CO_2, with fusible links whic will bring about automatic release when the temperature reache 160° F. Many of these are excellent when properly installed, bu it is obvious that a toxic agent should not be used in such device in any location where there is the possiblilty of the release fumes or gases being breathed by humans.

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Portable Fuel Moisture Scale

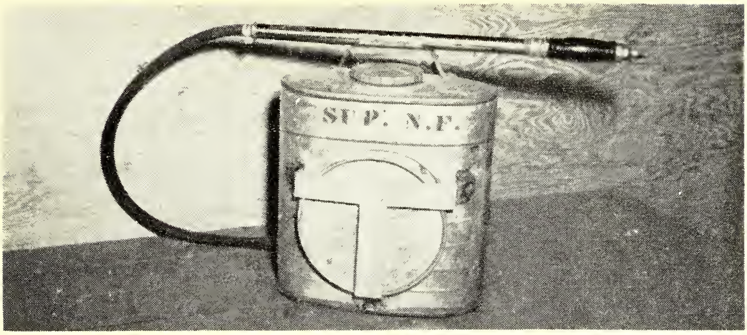
Increased research in fuel moisture problems and increased interest using paired sticks in the timber edge and in the slash as a guide to slas burning raised a demand for a portable fuel moisture scale that could l carried from station to station. Since none was available, the standard sca was adapted in the following manner.

A level vial was secured to the face of the scale near the graduation ar The scale was then put into a vise and the standard 100-gram weig attached to the balance in the usual manner. With the slide set at 100, tl scale was then rotated to obtain a reading of "0." In this position the lev bubble was set to read level. To operate, the scale is held at the top edge l the right hand and rested vertically on any support. The fuel moisture stic are hung on the scale, the level bubble is brought to center and held the while the fuel moisture is read from the graduation arc in the usual manne

Because some situations do not provide a place to rest the scale, a st with brackets was provided. This staff is a standard ½-inch by 4-foot dow rod with a short pin in one end. Two small angle aluminum brackets we attached to the center back of the scale plate. The bottom one had a ½-in hole drilled and reamed to allow the dowel to slide freely. The top brack had a smaller hole for insertion of the pin in the dowel. To operate, t dowel is slid through the bottom bracket and the pin inserted in the t bracket. The staff is rested on the ground, the scale grasped in the rig hand and the fuel moisture read as previously explained.

In some locations, wind swinging the sticks is a problem. This can solved by a sheet of metal bent in a "U" and staked in a vertical positi at the site. The scale is then rested in a position so that the sticks ha inside this wind deflector. A similar wind shelter may be made by drivi three 1- by 6-inch picket boards into the ground.—William H. Larson, *Ch Fire Warden, Washington Forest Fire Association.*

Bracket on Backpack Can for Canvas Bucket



A T-shaped bracket, cut from medium-gage galvanized tin, is soldered to a backpack pump can. This is a handy way to keep a collapsible canvas bucket readily available for filling the pump.—LOUIS F. DEYAK, *Fire Control Aid, Superior National Forest.*

☆ ☆ ☆

Fire Prevention Note

During the 1955 hunting season, the Coconino National Forest, Southwestern Region, used a short form letter as a means of contacting hunters and campers who were not in camp at the time the fire prevention guard or patrolman passed by. The mimeographed letter was printed on golden-orange paper to obtain greater legibility and as a reminder of the Forest Service Golden Anniversary. It read as follows:

Dear Mr. Hunter:

One of your Forest Rangers has visited your camp while you were out. The reason you probably picked this spot to camp is that it is located in a place you thought to be clean and beautiful. When you are ready to leave, please look at it once more and ask yourself if it looks the same as you found it. Others will appreciate anything you do to help keep your camp and the woods clean.

As you know, the forest is extremely dry and FOREST FIRES may start at any time. Please build your campfire on bare ground, in a safe place, away from logs, brush and litter. Make sure your fire is DEAD OUT whenever you leave camp. The Ranger who visited your camp may have some suggestions to make that may help you.

1. ....

2. ....

Thank you for your cooperation. Please stop one of our fire patrolmen if they can be of assistance.

Good luck on your hunt.

Very truly yours,

Forest Supervisor

By

There was also sufficient space on the form for the patrolman to offer suggestions that would help the sportsman to enjoy his stay in the Forest.

(This is a good reminder of a practice used from time to time in vario other Forest Service regions. For example, the "courtesy ticket" includ smoking rules in effect at the time. Thus, the visitor is informed on t specifics of safely using his Forest playground.—Ed.)—Franklin O. Carro *Assistant Fire Staffman, Coconino National Forest.*

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TV Helps Prevent Forest Fires in Texas

Texas leads the Nation with 35 television stations operating in the Stat Construction permits have been issued for an additional 10 stations. The are more than 90,300 television sets on Texas farms and ranches—nearly for every 3 rural homes.

Approximately 25 percent of all woods fires in Texas in 1954 we caused by hunters. To discourage them from smoking game out of holl trees and otherwise causing forest fires, much of the fire prevention effo in the State is directed toward hunters.

Chester O'Donnell, audio-visual aids specialist, Texas Forest Servi has prepared a series of station-break slides. The fire prevention messag station call letters, and channel number appear on each slide. Brief fi prevention copy is provided for the announcer to read while the slide in view.

Several other station-break slides on related subjects have been prepa and distributed to Texas TV stations. These include "Observe Arbor D and "Use Your Ash Tray." In addition, Texas television stations are mak extensive use of educational forestry motion picture films and some forestry programs.

Through the use of television the Texas Forest Service is bringing fo fire prevention messages to the homes of many people who were ne reached before.—E. R. Wagoner, *Associate Forestry Educator, Texas Fo Service.*

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproduction. Please therefore submit well-drawn tracings instead of prints.


SMOKEY
PLEASE BE CAREFUL...
with matches
with smokes
with campfires
with every fire!
SMOKEY
Remember-Only you can
PREVENT
FOREST FIRES

VOL. 17 JULY 1956 No. 3

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 17 Number 3

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A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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Forest Service, Washington, D. C.

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FIRE EFFECTS IN SOUTHERN HARDWOODS

E. RICHARD TOOLE AND J. S. MCKNIGHT [1]

Much of the bottom-land hardwood forest in the Mississippi)elta has burned repeatedly during occasional severe droughts hat create extreme fire hazards. The efforts of forestry agencies .re reducing the acreage burned. Even so, every person interested n forestry should become familiar with fire damage in this hardvood type. A single fire in a bottom-land stand can completely ındo 20 or 30 years of careful management.

THE STURDIVANT FIRE

In November 1952, a fire swept over a tract in the Yazoo-Mississippi Delta. It might have been just another fire, except hat it happened to burn in a stand where the Southern Forest Experiment Station had laid out an experiment to measure the growth of well-managed hardwoods. The fire knocked out the growth study, but it led, directly and indirectly, to improved knowledge about the effects of fire, and to suggestions for handling damaged timber.

The fire began early one morning and was not brought under control until early the next morning, by which time it had burned nearly 1,200 acres. As with most large blazes, it was hotter on some areas than on others, and hence caused varying degrees of damage to the timber. From all appearances, though, the damage on the 70-acre experimental area was typical of that over the entire tract.

At the time they burned, these 70 acres were beginning to show the benefits of an improvement cut made 5 years before. The main stand consisted of about 111 trees per acre that ranged in diameter from 6 to 26 inches. Three-fourths of these trees were vigorous and clean boled, likely to produce high-quality wood rapidly. In addition, a generous stand of seedlings and saplings was growing thriftily in openings where mature or low-grade trees had been logged or used for firewood.

The fire virtually wiped out this promising young growth. All seedlings and saplings up to one inch in diameter were killed outright. Trees between 1 and 2 inches in diameter did not fare much better: two-thirds of them were killed and most of the rest were damaged. Among trees between 3 and 5 inches in diameter, mortality was 35 percent.

But the worst damage, at least in terms of immediate financial loss, was to larger trees. Where the fire ran with the wind (head fire), or where logging slash from the improvement cut increased the fuel supply, 33 percent of the trees larger than 6 inches in diameter were killed outright. Of the larger trees that had been classed before the fire as having exceptional promise, 9 out of 10 were killed or damaged severely.

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[1] Delta Research Center of the Southern Forest Experiment Station, Stoneville, Miss., in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group. The Southern Forest Experiment Station is a part of the Forest Service, U. S. Department of Agriculture.

Where the fire burned across or against the wind (flank backing fires), or where there was no slash, damage was som what less. Even where the flames were least hot, however, 20 pe cent of the high-grade trees were either killed or damaged so bad that it was no longer a paying proposition to keep them in t stand.

Of course, there will be new growth to replace the loss in t seedling sizes. One year after the fire, over 3,000 sprouts or see lings per acre were found. Nevertheless, the fire set the seedli and sapling stand back at least 5 years, and it will take 60 or years to replace the larger high-quality stems that were killed damaged.

Damage to Individual Trees

Trees that are not killed by fire may be severely damag that they have little, if any, value. The bark on at least one si is usually burned and charred; at first glance this often appears be unimportant (fig. 1). However, when these trees are examin more closely, it is found that the charred bark adheres to de wood. By the third year rot will start its work.

It may take as long as 4 years after a fire for rot reach the heartwood, but once there it will spread steadily upwa at rates varying from a few inches to nearly a foot a year. Th what should be the most valuable part of a tree is rendered co pletely worthless after 15 to 20 years.

The amount of rot to be expected in the butt log of a tree pends largely on the size of the original wound and the ti elapsed since the fire. When over 100 wounded trees were amined shortly after the Sturdivant fire, it was found that white oaks and bitter pecan the area of the wound was nearly same as the area of the bark char (ratio 1:1). In red oaks, wound was generally 2½ times as high as the bark char, thou the width of red oak wounds was about the same as the width the char.

Should Damaged Trees be Kept in the Stand?

Death in larger hardwood trees can be determined without mu trouble. But when a valuable tree is only wounded, the for manager must decide if he can safely leave it for further grov or if he should salvage it before decay sets in. Experience w the Sturdivant fire yielded some suggestions for cruising or ma ing fire-damaged hardwood timber.

Trees killed or seriously damaged by the fire should be vaged as soon as is feasible, with due consideration for the cutt cycle, and the vigor and length of stem of each affected tree. generally a tree should be salvaged if:

1. The bark is charred for more than 6 feet above the stu (regardless of the width of the char).
2. The char extends around more than half of the tree's cumference and reaches more than 2½ feet above stump.

FIGURE 1.—*A*, The hardwood may appear little damaged immediately after a fire. *B*, 1 year later, cracks appear in bark. *C*, 2 years later, bark begins to fall off. *D*, 3 years later, rot starts its work on the underlying sapwood, and stem breakage may occur.

In estimating the extent of rot behind older wounds, and the rot to be expected in the future, it is helpful to keep in mind that, on the average:

1. Rot does not start in the heartwood until 4 years after a fire.
2. Wounds less than 2 inches wide are not important as a source of rot.
3. Rot exceeds hollow length about 2 feet.
4. Rot exceeds butt bulge about 3½ feet.
5. In 10 years, rot will extend 1½ feet above the original scar if about ¼ of the tree's circumference was damaged If more than ¼ of the circumference was damaged, the rot may go higher.

Fire Always Hurts Hardwoods

The Sturdivant fire was put out more than 3 years ago, but research on it and other burns has settled once and for all some facts that seem obvious but are often forgotten. In hardwoods there is no such thing as a harmless fire. All fires fry the repro- duction and wound the larger trees. Any wound bigger than a silver dollar is probably going to admit rot that will surely destroy the valuable butt log.

Hardwoods are indeed hapless in the face of fire.

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Tractor Tilt Indicator

H. A. Yocum has designed and installed a simple device on our crawler tractor that indicates the angle of tilt on a side slope. This practical indicator may be more useful than most of the commercial tilt indicators available. It particularly lends itself to adaptation for the wide range of stability between the various tractors used by the service.

The device is a plumb bob that swings inside a slotted bar with a dia[l] behind the plumb bob. The plumb bob swings from the hood above the instru- ment panel. The slotted bar is fastened to the hood with brackets and bolt[s] holding it tight against the instrument panel. This bar prevents the plum[b] bob from swinging away from the instrument panel when the tractor i[s] traveling upgrade.

The dial consists of five segments of a circle painted in three colors o[n] the instrument panel. The extreme limits of the green center segment indi- cate 15-percent slope; of the two yellow segments, 30-percent; and of the tw[o] red segments, 45-percent. This calibration allows a large safety factor. O[n] other tractors, and under other operating conditions, a different calibratio[n] may be preferred.

While the plumb bob is swinging in the green, no special safety pre- cautions are required of the operator. When it swings into the yellow, he i[s] required to start slowing down from maximum operating speed. When [it] swings into the red, he should come to a stop or nearly so, pick a less pre- cipitous route, and proceed at a speed of not over one mile per hour unt[il] safer ground is reached.

There is a slight amount of friction between the guide bar and th[e] plumb bob except when the tractor is perfectly level. The plumb bob won['t] hang up, however, even when the tractor is going up or down very stee[p] slopes, because the constant movement and vibration of the machine con- tinually shakes it free.

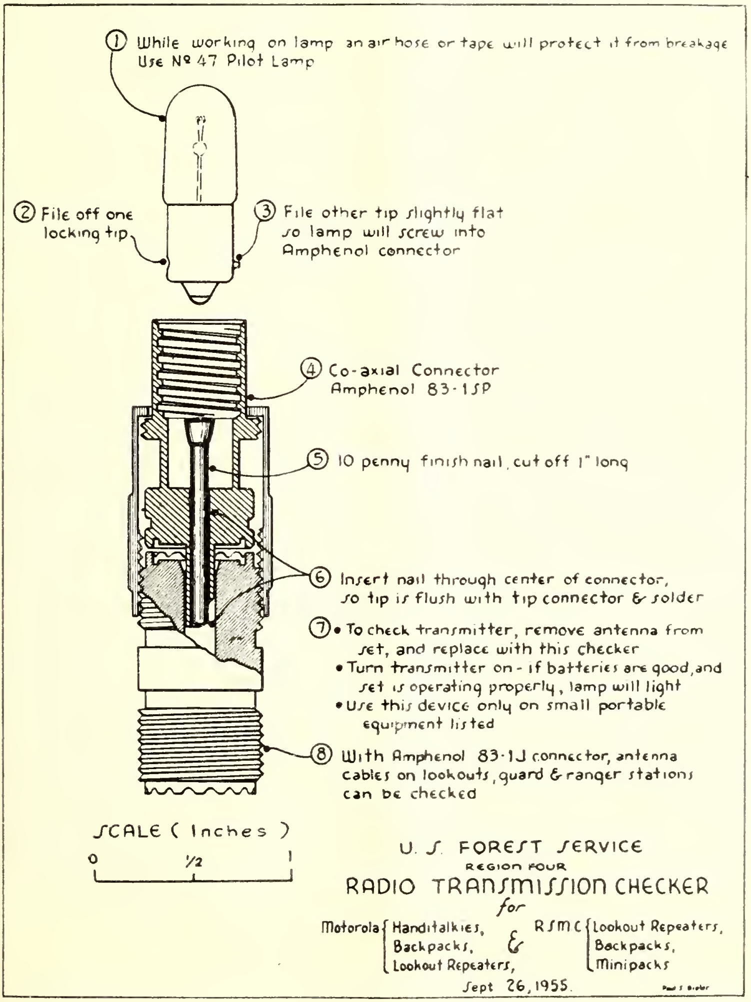
This device has worked satisfactorily, and we feel it can be effective i[n] reducing potential tip-overs, and is particularly useful for operator trainin[g] purposes.—H. H. Muntz, *Southern Forest Experiment Station.*

RADIO TRANSMISSION CHECKER

JOHN BARKDULL

Communications Technician, Boise National Forest, R-4

The radio transmission checker, as illustrated, has been made nd used extensively in Region 4 and was found to be satisfactory. t is also used with an amphenol 83-1J connector for checking an- enna cables. The cost of the unit is approximately $1. This



hecker will give nontechnical personnel a simple visual means for etermining whether the portable radio transmitter is operating ith normal output.

BRUSH SAWS FOR "HOT SHOT" CREWS

MICHAEL A. ROBERTS

Foreman, "Hot Shot" Crew, San Bernardino National Forest

The "Hot Shot" crew was organized to be a well-trained, fas hard-hitting line hand crew. Toward this goal foresters are a ways alert to ways and means for securing faster and better re sults in fireline construction with less fatigue for such a crew. I is well known that line construction with brush hooks and axes i good but very slow and tiring. The problem of converting chai saws for use on brush, particularly on northern slopes in souther California, was thoroughly considered, and when trial proved thi type of saw effective, a number were purchased for this use.

The 2½ horsepower chain saws had a 16-inch bar and Ore gon chipper type chains; the Oregon XX type chain was also pur chased. Only one piece of brush could be cut at a time with thi type of chain saw because of the hazard of hitting the end of th saw on other brush, which made the saw jump back and en dangered the operator. To reduce this hazard and make the sa more effective a bow type attachment was purchased (fig. 1). Th chain saw demonstrated on the fireline that it would cut ½-inc brush up to very heavy oak 12 inches in diameter with ease.

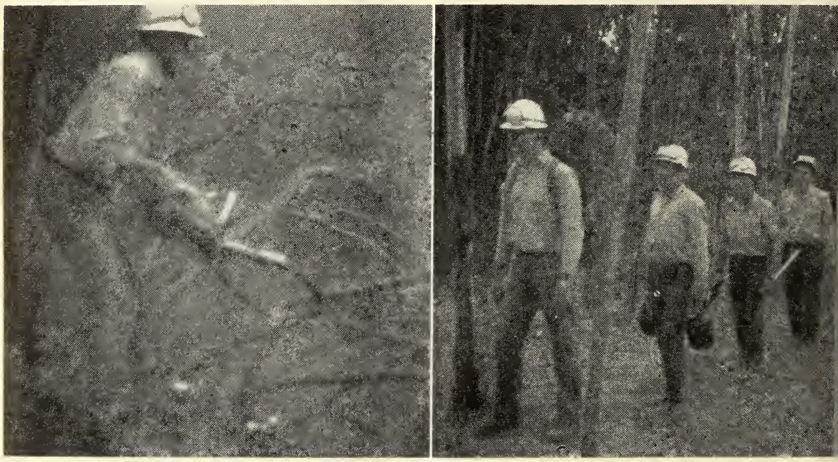


FIGURE 1.—*Left*, Saw with bow type attachment cutting brush. *Right*, Bru saw team packing in.

Teams of four men work together. One man operates the sa while the other three team members throw the brush the operat cuts. A man works as an operator for half an hour at which tir another member of the team takes over his job. In the develo ment of these teams problems of safety were encountered.

training program was necessary to teach the teams working together how to use these saws, since the group must be ever conscious of the hazard of the chain saw while in operation.

Transporting the brush saw to the job assignment was the next problem. A rucksack, used as a carrying case, proved very satisfactory for its weight of only 30 pounds. An extra quart of oil, a quart of gear oil, extra chain, and tools fitted easily into the extra pockets on the bag. A piece of 1½-inch condemned canvas hose was used to make a guard for the chain.

Judging by the work accomplished in using these brush saws, we would recommend that they be tried by all "Hot Shot" and other organized crews. Brush saws can be effective, and once tried may well take an important place on the fireline.

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Transporting Box For SF Handi-Talkie Radiophone

A metal box lined with sponge rubber to protect a SF handi-talkie radiophone while being transported by motor vehicle has been developed on the Black Creek Ranger District by Mechanic's Helper Elisha Bond (fig. 1). One radiophone was carried in such a box in a Forest Service pickup for 18 months without developing mechanical failures. In addition to the protection afforded by the shock-absorbent qualities of the sponge rubber, the radiophone is also protected from dirt and dust.

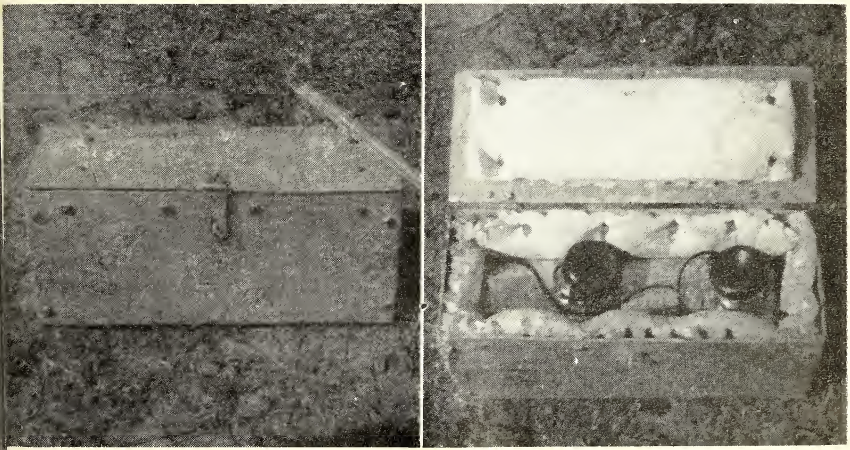

FIGURE 1.—*Left,* Closed radio transportation box constructed of aluminum plate. *Right,* Opened box showing lining of sponge rubber and radiophone in place.

The box is constructed of ⅛-inch aluminum plate and is lined with 1¼-inch sponge rubber. Although the sponge rubber was bolted to the box, an adhesive could be used satisfactorily. A box 16 inches long, 6½ inches wide, and 7½ inches high will accommodate the SF handi-talkie radiophone. It is recommended, however, that the box be built 19 inches long so that a spare set of batteries can be stored in the container. The cost of the box is more than offset by the savings in radio repairs during a one-year period.—DONALD A. POMERENING, *District Ranger, Mississippi National Forests.*

TRUCKS FOR "HOT SHOT" CREW ON THE SAN BERNARDINO NATIONAL FOREST

Michael A. Roberts

Foreman, Del Rosa "Hot Shot" Crew, San Bernardino National Forest

Equipment plays an important part in the effectiveness of a fire fighting crew. To assist the well-trained "Hot Shot" crew on the San Bernardino National Forest, trucks and equipment have been developed for their use. The basic equipment consists of a ½-ton pickup with seats and side rails and two 1½-ton stakesides with toolbox seats, completely equipped with handtools, portable radios, headlamps, rations, and two brush saws.

Figure 1.—*Left*, Truck ready to roll; rear step raised and in place for traveling. *Right*, Crew unloads by using handrails and the step developed at the Arcadia Equipment Depot.

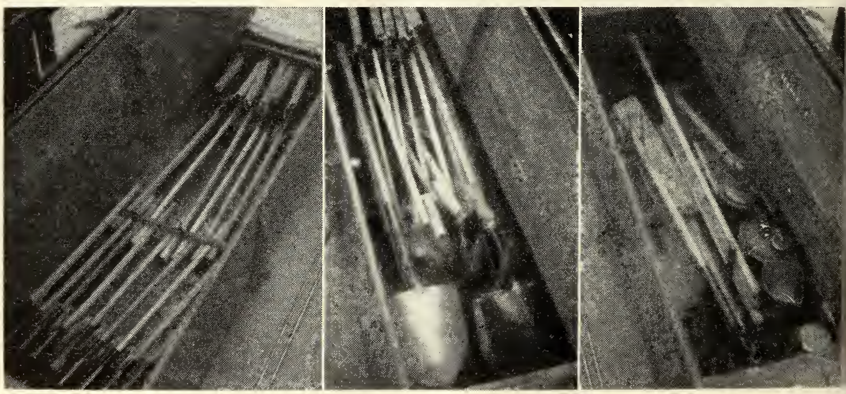

Figure 2.—Tools must be available for distribution in a minimum of time. These three toolbox seats contain brush hooks and double-bitted axes (note the used cotton hose as guards for exposed cutting-edges); shovels and pulaski tools; and McLeod tools, gas for brush saws, and extra chains.

Since a "Hot Shot" crew should basically be a self-sustaining unit, the following tools are carried on each crew truck:

Shears, pruning .... pair	2
Brush bobbers	3
Hooks, brush	10
Pulaski tools	8
Shovels, long-handled, round-pointed.	10
Hose tool guards	24
McLeod tools	8
Axes, double-bitted	7
Saw, felling	1
Handles, saw	2
Wedges, wooden	4
Hammer, sledge, 4-pound	1
Oil, saw .... quart	1
Saws, brush, chain	2
Chains, brush saw .... extra	2
Fuel for brush saw, in safety cans .... gallons	2
Oil, brush saw .... quart	1
Oil, gear, brush saw .... quart	1
Files	18
Hose, file holders	18
File guards	18
Handles, file	18
Canteens, 1-gallon	20
Lamps, electric, head	24
"A" batteries .... carton	1
Fuses	24
Gopher gassers .... carton	1
"B" batteries .... extra	2
Radio, handi-talkie	1
Rucksacks	2
Knapsacks	9
Rations, emergency .... boxes	2
Kit, first-aid, large	1
Kit, first-aid, cylinder	1
Kit, first-aid, belt	1
Kits, first-aid, pocket	7
Kits, snake bite	4
Water cooler, 15-gallon	1
Dispenser, paper cup	1
Extinguisher, fire	1
Blocks, chock	2

With this equipment available, the crew can use the truck as an operating base during the initial work period. Damaged tools may be exchanged for new ones. Damaged tools should be replaced as soon as the crew returns to the fire camp or headquarters.

The crew trucks are designed to carry men and tools safely to the fire. After arrival crews must unload as quickly as possible for the initial attack (fig. 1). Tooling up and hitting the fire must take only minutes (figs. 2 and 3). Additional information about the equipment and its arrangement may be obtained through the Forest Supervisor, San Bernardino National Forest, P. O. Box 112, San Bernardino, Calif.

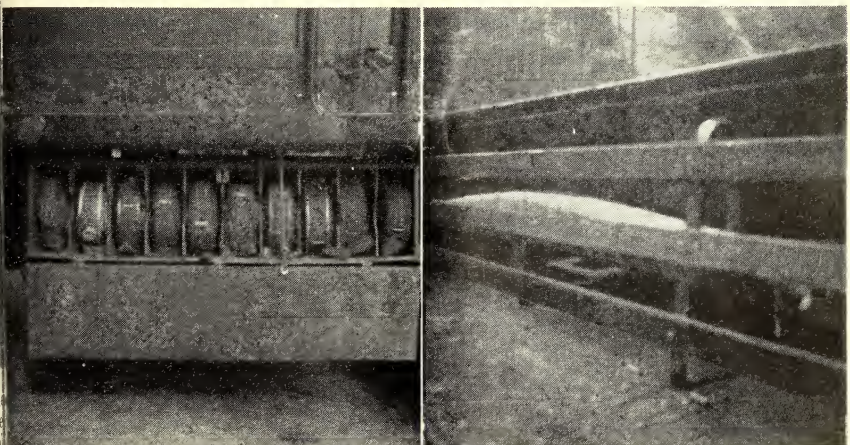

FIGURE 3.—*Left,* Two canteen boxes, one installed on each side underneath the truck bed, keep water cool. *Right,* A felling saw.

MECHANICAL TRAIL PACKER HITS THE SILK

A. B. Everts
Equipment Engineer, Division of Fire Control, Region 6, U. S. Forest Service

[This progress report illustrates the appeal and versatility of use o automotive trail transportation equipment.]

In the July 1955 issue of *Fire Control Notes,* District Range Parks of the Payette National Forest reported on "A Mechanica Mule." In a footnote the editor remarked, "At least five othe models of this versatile machine are being designed, tested, or pro duced by private and government agencies." This article report on one of the commercial models and some of the modification that have been made to it (fig. 1).

There are at least 30 of these machines in use in the region most of them by trail crews. They are so common that they are n longer a topic of conversation and it is quite probable that we hav not heard some of the interesting stories regarding their use Packing lookouts in and out of their stations is commonplace. Con siderable ingenuity has been exercised by various individuals fo improving the units for trail use. Stands of various kinds hav been devised to hold the loaded packer upright while loading an unloading, and during trail stops.

The Wenatchee Forest has one equipped with a winch whic is used to pull out small stumps on a trail construction job. Thi forest has also recently completed a project in which they hav modified a packer into a mobile trail compressor unit. The uni complete with compressor, drill steel and bits, jackhammer an accessories, weighs 655 pounds, including the weight of the packe

Figure 1.—This model of the packer weighs 175 pounds and is powered wi a 2½-hp. 4-cycle motor. Gasoline consumption is 16 miles to the gallo two speeds, 5 m.p.h. and 2½ m.p.h. Present cost is $175 f.o.b. factory.

The Mt. Hood Forest has used the packer for transporting rolls of paper for covering brush piles in connection with a clear-cut slash-disposal experiment. It was also a Mt. Hood 2-man trail crew that made a 70-mile, 10-day trail-opening expedition in which all their tools and supplies were transported on a packer.

The Wallowa-Whitman Forests have a trail kitchen packer, complete with plywood built-ins, that brings a touch of convenience, if not luxury, to an isolated camp (fig. 2).

We have not yet heard of anyone using the packer as a pumping unit or for transporting portable pumps into a water "show." If it hasn't been done, it's just a matter of time, along with a lot of other uses.

The manufacturer of the packer has a companion unit called the "trail grader," which is giving excellent results on trail construction jobs. This unit has considerable promise as a fireline digger and, while we do have some figures on rates of fireline construction, we are not yet ready to release the unit without more field experience. We do believe that in many types of fuel the grader will do the work of six to ten men with handtools.

Also now, Francis Lufkin, Aerial Project Foreman of the North Cascade Smokejumper Unit, has brought up the idea of using the packer to retrieve smokejumper equipment. What's more; Lufkin has demonstrated that his idea is sound.

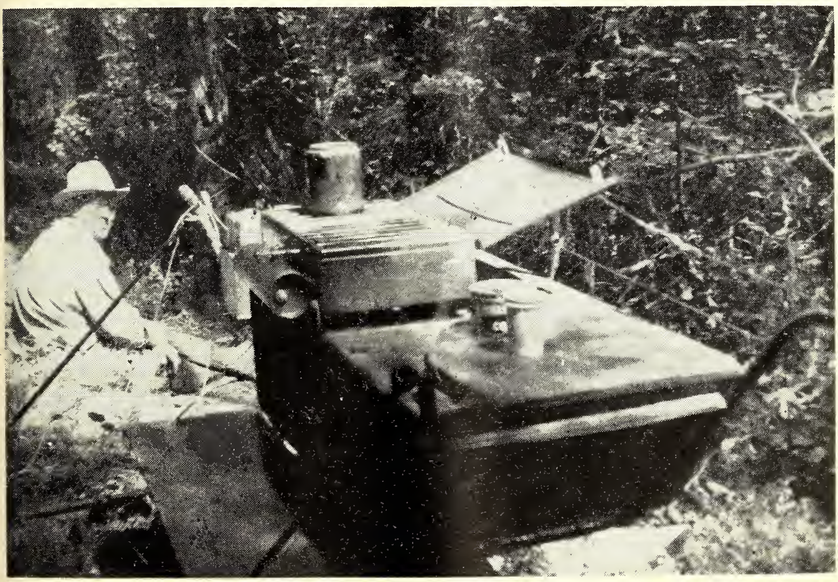

FIGURE 2.—The Wallowa-Whitman Forests trail unit with built-in plywood box. Complete unit includes the following equipment: Two axes, 1 hazel hoe, 1 crosscut saw, 1 pruning saw, 2 canteens, 3 sleeping bags, 3 knapsacks (personal), 3-man mess kit, 1 gasoline lantern, 1 gasoline two-burner stove, 1 tarp, groceries for three men for one week. Approximate load is 300 pounds.

A smokejumper's "come-out" equipment, including his fire tools, which are dropped to him, weighs about 105 pounds. This is a sizeable load, even for the young huskies that hit the silk on these back-country fires.

In times past, it was the procedure for the jumpers to backpack their equipment out to the nearest trail where it would be picked up by a packstring. This still occurs to be sure, but in this changing world packstrings certainly aren't increasing in number, and packing is beginning to be spoken of as a "lost art." There are still plenty of mules. The same cannot be said of packers, however. The result is that on many fires the jumpers backpack their equipment "all the way out."

Mr. Lufkin wants to change this, at least on the long packs, and it looks as though he's going to do it. He made some changes in the packer:

(a) Changed the clutch arrangement to contain its own tighteners and for easier control.

(b) Added side stands to hold the machine upright while motionless.

(c) Added a crazy wheel in the rear to eliminate the need for fore and aft balancing.

Then Mr. Lufkin devised a way to break the machine down into two parts since, with the accessories, it was too heavy and too awkard to get it out of the aircraft door easily (fig. 3).

FIGURE 3.—Packer, in two sections, packaged for dropping. Note the paddin under the engine on the left-hand section, designed to lessen the landin impact.

There was one more important step: training. After success fully completing test dropping, a few of the jumpers were give training in assembling the unit, how to start the engine, how t

use the clutch and tighten the belt, etc. They had confidence in the machine before it ever came drifting down to them "out of the blue," as it did shortly afterward on the Hungry Ridge fires. There were two fires, both started by lightning, a little over a quarter of a mile apart. Four jumpers went down, two to a fire. They got their fires and mopped them up. Then they loaded their equipment on the packer, 410 pounds of it, and headed out (fig. 4).

FIGURE 4.—Smokejumpers coming out from the Hungry Ridge fire over an old sheep driveway.

The packer has its limitations, but its area of operation is increasing. Region 6 is beginning to talk about better trail maintenance, a different kind of a water bar. Fording streams is a problem. The Wenatchee Forest personnel say that in many crossings they can solve this by a small cable stretched across the stream. They simply hook the packer to the cable and skyline it across, load and all.

There is no doubt about it; the mechanical trail packer is here to stay. It's not at all improbable that within 5 years one or two of these units will be standard equipment at many ranger stations, at least on those districts that have an extensive trail system. You will hear repeatedly as you talk to the boys who are pioneering their use, "Sure, there's work connected with them. So what! You don't have to round 'em up when you crawl out of the sack in the morning. And you don't have to feed 'em all winter long like you do the long-eared hay burners."

FIRE HEADQUARTERS SUPPLY CABINET

JOHN A. ANGUILM
Assistant Regional Supervisor, Region 1, Michigan Departmen[t] of Conservation

A few years ago 3 extra-period fires, i. e., fires not controlle[d] by 10 a.m. of the day following discovery, taught us the desirabilit[y] of having a well-organized and well-equipped fire headquarter[s] supply cabinet ready to roll on a minute's notice. Such a cabine[t] was designed and built for us by our Central Repair Shop at Gay[-] lord, Mich. (fig. 1).

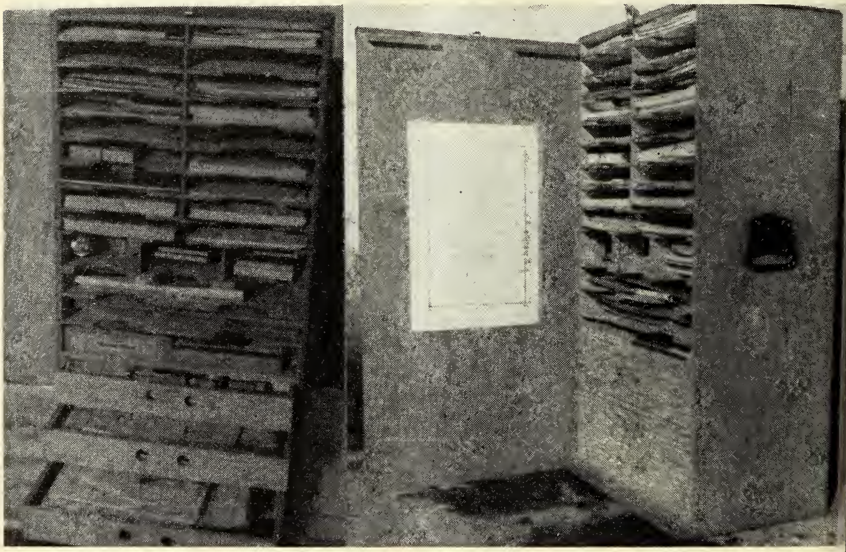

FIGURE 1.—Fire headquarters supply cabinet.

The cabinet is made of ½-inch plywood with ¼-inch divide[rs] and is 19 inches wide, 36½ inches high, and 12 inches deep. I[ts] removable door recesses into the box foot and fastens at the t[op] with a trunk-type fastener. On a fire, this door serves as a tab[le] top; a layout of the box is posted on it (fig. 2).

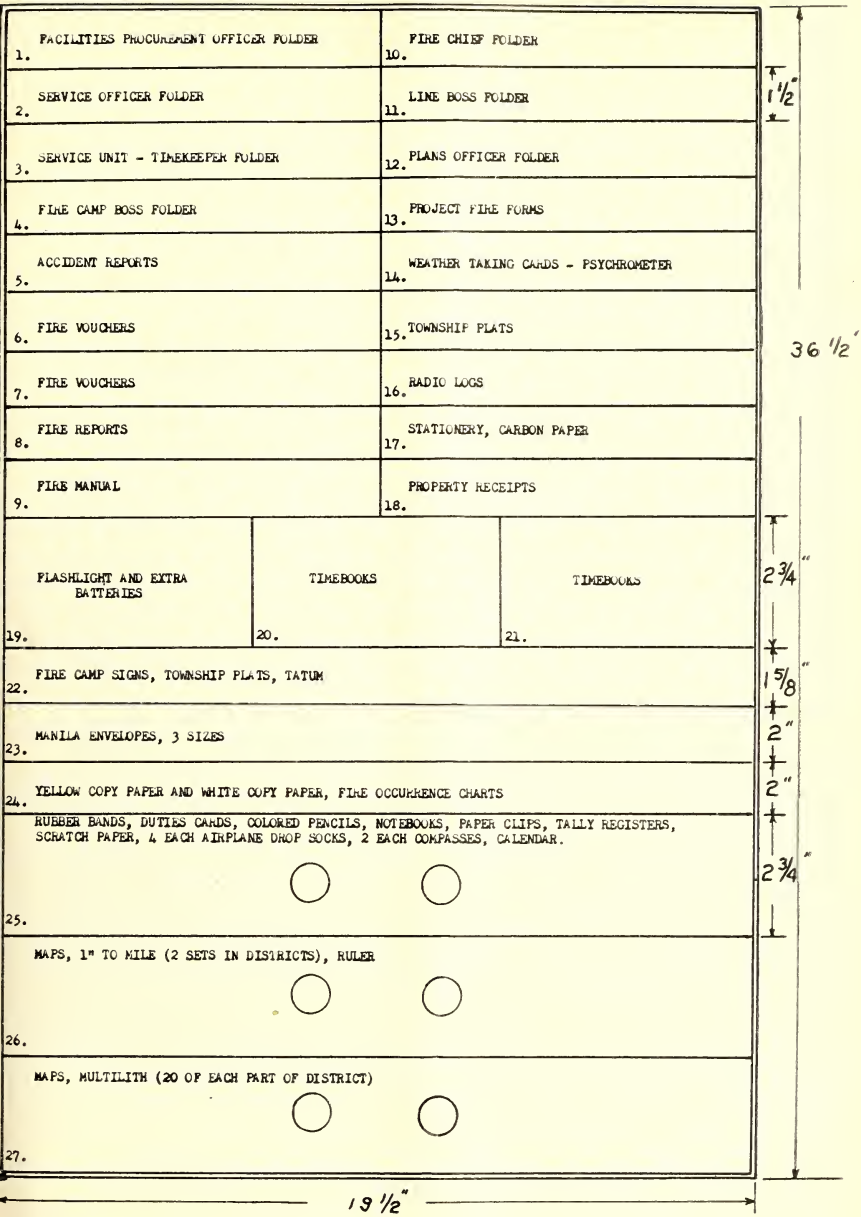

FIGURE 2.—Supply cabinet layout.

SIMPLIFICATION IN DISPATCH SYSTEMS

MAX A. BRADLEY AND GILBERT I. STEWART
Michigan Forest Fire Experiment Station, Michigan Department of Conservation

From the beginning, organized forest fire control in North America has depended upon fire detection and map systems. These, differing somewhat in detail according to the agencies involved, have remained basically the same. Detection has come chiefly by actual observation of fires from elevated positions—ultimately towers—strategically located. Fire finding instruments have also differed greatly, even though variations are chiefly refinements. All detection systems utilize "cross shots" from two or more towers measured in azimuth directions. When these readings are plotted on a dispatch map at some headquarters, the map location of a fire is established. Until this is done, initial action on suppression cannot be undertaken efficiently. However, once the map position is established, a great deal of efficient action can start promptly, for not only is the location known, but also associated information is available immediately dealing chiefly with base features, forest cover, and water supplies.

Functions of detection cannot be separated from those of dispatch, and good map systems constitute the basis of all effort in these fields. Completeness and accuracy are essential in maps themselves, but equally important is the accuracy of plotting azimuth readings from tower sightings.

Almost without exception surfaces of dispatch maps have been dominated by azimuth circles stamped, printed, or pasted upon them, the center of each circle indicating the position of a tower. In those instances where towers were located fairly near each other, circles overlapped or became so numerous that base features were seriously blocked out. Usually, reconstructions of tower readings were made with cords stretched from the centers of the azimuth circles concerned, and crossed to establish the map positions of fire. Even though the desired results were obtained in establishing positions of fires, many disadvantages have been recognized.

The Michigan Department of Conservation recently undertook to investigate means of improving instrumentation of fire detection, as well as map systems employed in dispatch. Investigative work was broken down into two major phases; fire finding instruments and map systems.

Improved types of fire finding instruments were reported upon in *Fire Control Notes* for April 1955. Work progressed simultaneously on map systems, and in May 1955 all map methods existing prior to that time were declared obsolete, to be supplanted by a new system as soon as replacement maps could be issued.

The study of existing methods brought out that improvements could be attained only if the following features could be assured:

1. Accuracy must be assured in reconstructing cross shots from towers. Also accuracy should be consistent and comparable with that guaranteed by fire finding instruments.

2. Full details of base features must remain visible, not obliterated by azimuth circles.

3. Maps must be replaced less often, their details protected from fading as much as possible, and their surfaces shielded from abrasion and dirt.

4. When replacement of maps becomes necessary no changes should occur in the positioning of markings from which azimuth readings are taken.

5. Means should be provided for setting off two or more simultaneous readings from any tower if it should be concerned with more than one fire at the same time.

6. The system of "Cross out" must not require pencil marking on the surface of a map, nor mar its surface by holes from pins, thumb tacks, or other markers.

Obviously the old methods could not be retained, and accomplish these improvements. By May 1955 an improved method had been developed. Its workability depended upon a new instrument combining an arm or arrow and an azimuth circle. This instrument, which has been called the "protractor arrow," was designed and perfected at the Experiment Station (fig. 1). It assured realization of all requirements listed above.

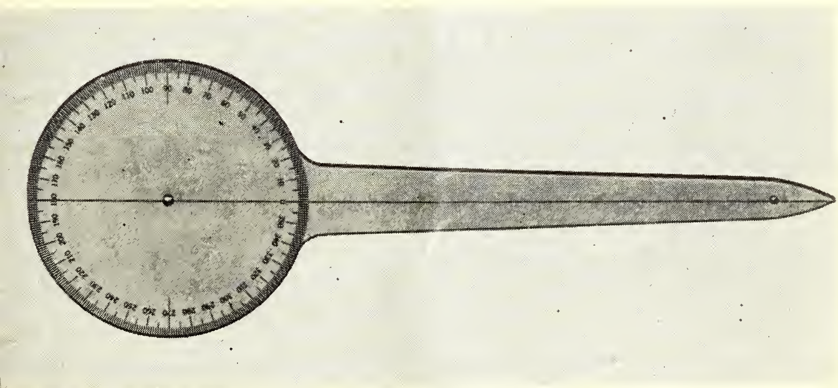

FIGURE 1.—The plastic "protractor arrow."

The protractor arrow was designed for production in transparent plastic, and several custom-made samples proved its practicality. Detailed specifications were formulated at the Experiment Station and, along with drawings, submitted to manufacturers. Satisfactory bids and estimates were received, and subsequently 1,500 of the instruments were ordered (fig. 2).

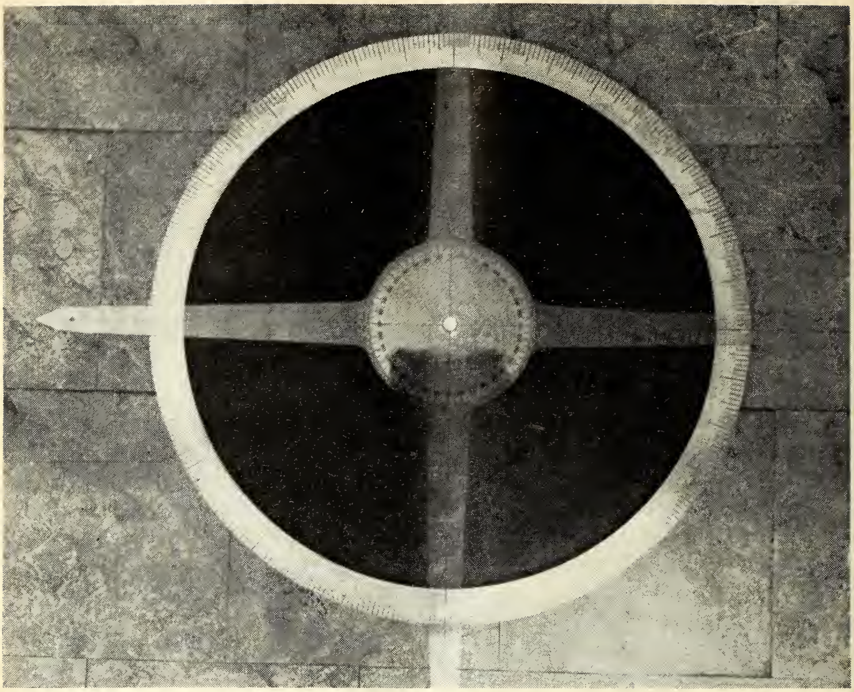

FIGURE 2.—A graduated gage was developed for testing the accuracy of protractor instruments. They were checked against each other in stacked position and on the gage as well.

The new maps bear no azimuth circles on their surfaces. Each map is mounted on relatively soft composition board that is laminated to a hard backing panel known as Novoply. The lamination is $\frac{7}{8}$-inch thick, and the entire panel is framed with light aluminum channel. A plastic coating is applied by brushing the surface of the map. It dries hard, clear, and transparent, leaving every map detail clearly defined and visible.

At the time of map printing, each tower location was marked with a short line extending north from the tower position. After maps were mounted and framed, a small hole was drilled at each tower location (fig. 3), threaded screw posts were pressed, friction tight, into these holes from the back of the map panel. Thumb screw studs can be inserted into them from the face of the map. Each protractor arrow is center-drilled to accept the screw stud; it can be clamped against the surface of the map and held in any position required by the azimuth reading (fig. 4). The "zero" or north line serves as the orientation point for any desired protractor setting.

At the present time six protractor arrows accompany each dispatch map; more can be issued with larger maps that include greater numbers of towers. Ultimately all maps used on towers will conform to this same system, and three to six protractor arrows should serve the need of each tower. Any arrow can be

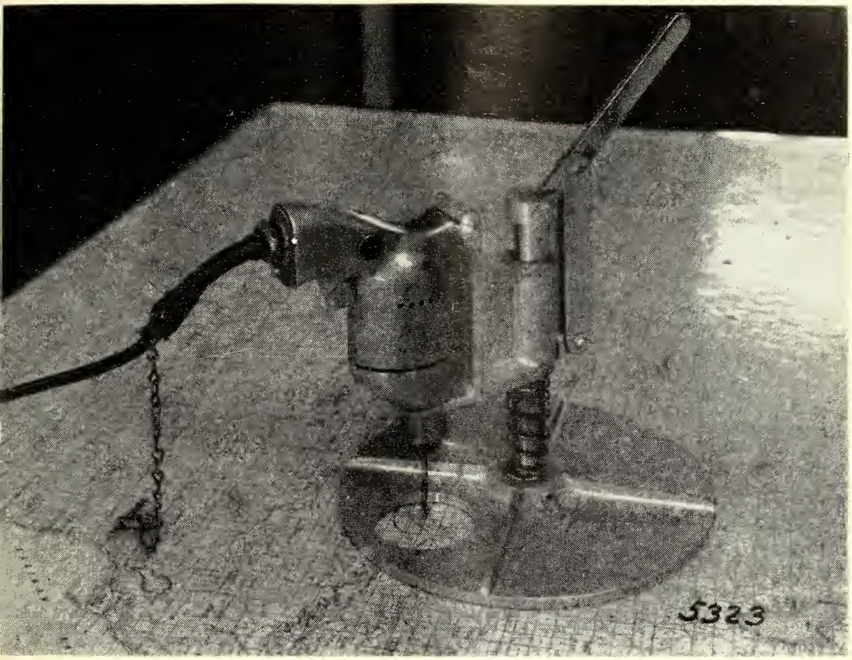

FIGURE 3.—Equipment developed for drilling map panels at tower locations. It is essential that every hole be accurately centered and drilled in exact alinement with the "zero" line already placed on the map surface. The circular opening in the base of the stand contains a transparent disk; a locating hole insures placement of the drill directly over each tower location.

moved about at will, and clamped at any tower location. If any one tower should be involved in more than one fire at the same time, arrows can be stacked on that particular screw post, and made to point in the required number of directions. The system can be used identically at all dispatch headquarters and towers.

A project to produce all of the dispatch maps required for issue to field headquarters and administrative offices throughout the State was finished in October 1955. All maps will be put into service for the fire season of 1956.

Changeover to this new method made obsolete all existing dispatch maps. However, future economy will be realized in a number of ways. Map replacement is expected to be much less frequent. The plastic protractor arrows are of high quality and should be usable for 10 years. When crossed, the centerlines of arrows establish the location of a fire very clearly; the setting can remain fixed as long as desired, and no marking of any kind need be made on the map surface. All techniques utilizing cords, with their attendant weights, springs, magnets, and stick pins are eliminated.

The protractor arrows have printed figures sandwiched between two layers of plastic. Graduations are very accurate, and permit plotting azimuth readings with no instrumental error. The

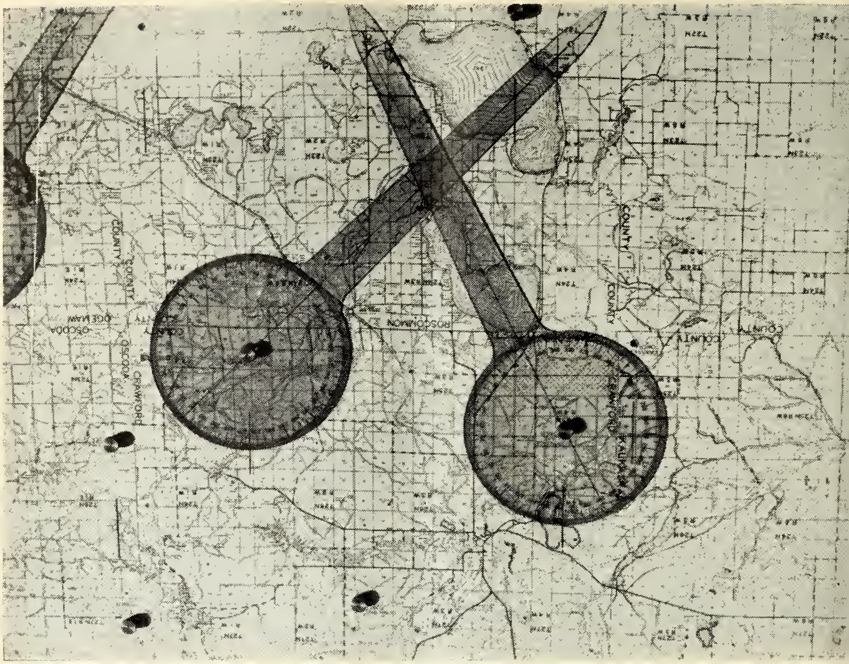

FIGURE 4.—Each tower location on the dispatch map is provided with a bas screw post. Thumb studs screw into them from the front of the map an clamp the protractor arrow in any desired position. Note the concis intersection of center lines. Surface of the map is completely free any other details that detract from map purposes.

azimuth circle is 5 inches in diameter, total length of instrume is 14½ inches, thickness is .060 inch. The material is classed clear vinylite. Further information can be obtained from th Michigan Forest Experiment Station, Michigan Department Conservation, Roscommon, Mich.

SELECTING AND TRAINING DISTRICT FIRE WARDENS

FRANCIS L. COYLE

Forestry Aid, Mio Ranger District, Lower Mich. National Forest

A successful warden force depends upon the men selected. They should be picked for leadership, ability to get along with people, geographic location, availability, and willingness to cooperate with the Forest Service. Just because a man lives in an area where a warden is needed and has a telephone does not make him a competent warden. Even if he has had experience on fires and is well acquainted with his zone, if he is unwilling to cooperate or to follow orders he is of little use.

After selection the warden's importance in the fire suppression program should be made clear to him. He should know that he was selected because he is respected by his neighbors, because of leadership abilities, because of good judgment, and because of willingness to cooperate. District personnel should visit their wardens when in the locality whether during the fire season or not. Regardless of the occupation a warden may have—farmer, businessman, logger, or resort owner—he should know we are interested in him and are depending on him. His Fire Warden sign should be prominently displayed, and his fire cache box should be kept in a neat condition.

To train new wardens and to bring experienced wardens up to date, warden meetings are usually held annually. An all day meeting should be planned to present the latest skills, techniques, and new equipment for fire fighting. Although our wardens do not receive pay either for their time or mileage, we have almost 100 percent attendance. This is in spite of the fact that some of the wardens drive 30 miles one way and most of them lose a day's work. This is partly because our wardens realize we are proud of them—and we don't hesitate to tell them so!

The first hour is usually spent in introductions; in passing out warden cards, books of burning permits, franked envelopes, and zone maps; and in having the wardens sign equipment agreements.

Next on the program is a discussion of last year's fires. Here again the wardens' work is stressed. Specific techniques that have proved helpful are pointed out. This leads logically to future work and methods by which the wardens can assist us in prevention as well as fire suppression. These include talking to people, posting fire prevention material in their zones, and advising their neighbors when it is safe or unsafe to burn. Fire fighters frequently have suggestions of value and their comments are encouraged.

If time is left before lunch, a movie on fire can be shown. Since new films are available, the same film should not be shown year after year.

After lunch take the wardens for a field demonstration on new equipment acquired since the last meeting. The men should be given a chance to use the equipment and to ask questions about its use. If new equipment or tools have not been acquired, the wardens can be organized for a project fire setup. Select a fire boss and explain the project through him. Instruct the group on how the fire boss should select his sectors and appoint such assistants as sector bosses, line bosses, tractor and tanker unit bosses, time-keeper, and radio operators. Each position and the reason for each one should be explained; maps and blackboard can be used to illustrate reasons for deployment of men and equipment. This simulated exercise can be made more interesting by such activities as having spot fires occur, and studying wind shifts. Questions and comments should be encouraged. In inclement weather this project can be held indoors.

No demonstration should last more than 2 hours. The final 2 hours of the meeting should be an open discussion. The wardens should know that we will support them. They have authority to issue burning permits, they may refuse permits if they believe it unsafe to burn. Also if some people in their zones burn promis-cuously, we will do all we can to prevent further violations even if court action is necessary. At this time the wardens are asked to present their particular problems and we answer their questions if possible. If not, we get the answer for them at the first opportun-ity. Wardens should be asked for comments, suggestions, and criticism on the work of the Forest Service in fire prevention and control. The meeting should stop early enough so that those who have important chores, especially farm ones, can get home to do them. But anyone who still has questions can stay for help in their solution.

After the warden force has been set up, the wardens should be used as much as possible. They should be dispatched on any fire in their zones, even though a Forest Service crew could handle the fire. The wardens should also be used as reinforcement in adjoin-ing zones; they should be utilized as much as possible as line or sector bosses on project fires. A good warden force can easily be-come a poor one, especially if fires occur in the wardens' zones and they are not used. Proper selection, training, and use of district fire wardens will result in a good warden force.

REFLECTIVE PREVENTION SIGN FOR PROTECTION VEHICLES

Martin E. Craine
Assistant State Forester, Utah Board of Forestry and Fire Control

While trying to take advantage of every known medium for the promotion of wildland fire prevention in Utah, one day we suddenly awoke to the fact that our own field vehicles were reaching into every corner of the State without carrying a direct plug for fire prevention. Immediate steps were taken to put this free advertising space to use (fig. 1).

Figure 1.—Utah Board of Forestry and Fire Control reflective prevention sign. The first 5 signs were produced in the State Road Commission sign shop at a total cost for labor and material of $32.50, or $6.50 each.

The signs were to be as large as practical for the vehicle tailgates. We wanted the message in large letters, legible from a distance and hard to overlook. This demanded use of the shortest possible phrase. Each sign was to be a unit that could readily be removed from a vehicle for refinishing or for transfer as vehicles are replaced. We selected 8-gage metal for the base material. So it would be equally effective in hours of darkness, each sign was made of reflective material. The finished product is black letters on a white reflective background with overall dimensions of 10 by 48 inches.

ADJUSTABLE TRAILER HITCH ASSEMBLY FOR STAKE TRUCKS

CLAUDE L. SMITH

Equipment Repairman, Michigan Department of Conservation

Fire control people frequently find they need to enlarge their truck fleet in high hazard periods by renting private trucks. Among the jobs for these rented units is delivery of trailer-mounted fire pumps, plows, and pipe and hose outfits to fire locations.

Our Norway station requested a trailer hitch assembly that could be easily installed and removed from any stake truck they might procure for temporary fire duty. We made up the illustrated hitch in 1953 (figs. 1 and 2) and in 1955 produced 20 additional units for use at other stations.

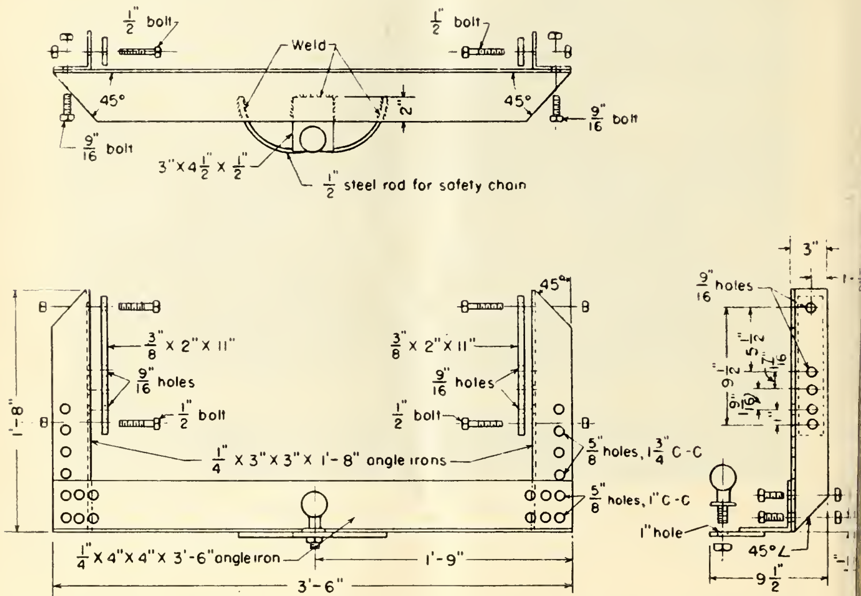

FIGURE 1.—Construction details of adjustable trailer hitch assembly.

This hitch is easily fastened (without boring holes) to th stringers of a stake truck by use of clamp plates. Several holes i the clamp plate and in the upright angle iron permit adjustmen to a snug fit over the stringers. Holes drilled in the upright angl iron permit setting the hitch at the desired height. Extra hole drilled in the crosspiece of the hitch permit adjusting the widt to the varying width between truck stringers.

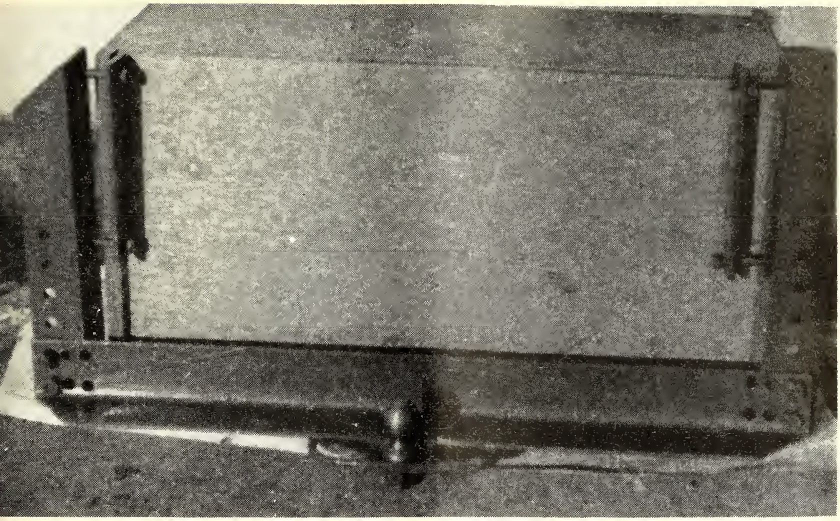

FIGURE 2.—Trailer hitch assembled.

CAUTION: This hitch is for temporary emergency use; because the bolts can work loose, the assembly should be checked frequently. Care should also be taken to see that the trailer is not loaded too heavily.

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Test-of-Friendship Fire

To the long and varied list of causes for forest fires, a new one was added last month.

The report comes from the Pleasant Hill District of the Ozark National Forest that a 59-year-old resident of that area set fire to his farm buildings last month to find out, as he told law officers, "if he had any friends who would come to help him put it out." Except for a crew of U. S. Forest Service men, no friends came. They controlled the blaze after it had spread over seven adjoining acres of National Forest land.

In court, the judge, prosecuting attorney, and witness were sympathetic. The old man was fined $25 for letting a fire burn to other lands, but a 90-day jail sentence was suspended, he was placed on probation for 6 months, and a charge of drunkeness was dismissed. Yet, on leaving the court of justice, the old man still seemed puzzled as to the extent and quality of his friendship.—*Quarterly Review,* Vol. VI, No. 4, Forest Service, U. S. Dept. Agr., Atlanta, Ga. Oct. 1955.

FIRE CONTROL PRACTICES: A TRAINING COURSE

CRAIG A. GIFFEN
Assistant District Ranger, Tahoe National Forest

For the past two years the Tahoe National Forest has used a different approach to fire control training at its annual fire training meeting. Several phases are integrated into one basic course for first and second year fire protection personnel. Classes are limited to five or six trainees each so that individual trainees can actively participate.

Prior to use of this method our fire training meetings depended on the lecture-demonstration type of class. Fire behavior, line location, line construction, initial attack procedure, mopup practices, and other courses were taught to groups of 20 to 40 trainees. Attempts were made to encourage individual trainee participation, but in too many cases most trainee activity was confined to looking and listening. Even the final crew-sized fire, culmination of our fire training meeting, took on the appearance of a demonstration for spectators. There was simply no opportunity for large numbers of trainees to actively participate.

Our new technique, called the "Fire Control Practices" course, is alloted about 3 days of our normal 4-day training meeting. A short orientation lecture and a required course in use of basic fire fighting handtools must precede it.

The 40 to 60 first and second year men attending are divided into groups of about 6 trainees each. Each group is assigned to an instructor who is assisted by a "demonstrator" and a "fire stopper." The more experienced personnel either attend specialized classes designed for their particular needs or they serve as demonstrators and fire stoppers.

The "Fire Control Practices" course aims to teach the principles of fire control by the use of many separate lessons. Each lesson stresses one principle or basic point in fire behavior, line location, line construction, initial attack, or mopup. Every lesson uses an actual fire. For the first several lessons very small fires are sufficient, maybe only a foot or two across, but the fires and the smoke are real. With classes small, interest is high. Informal explanation is necessary, to be sure, but an outdoor laboratory with lots of small fires is the key; individual trainee participation becomes a reality.

The first lesson might logically be a demonstration of fire behavior under the simplest possible conditions: No wind, no slope, and fuel of pure type and of uniform density and moisture. Grass or pine needles are very satisfactory and provide a good base for discussing the fuel-heat-oxygen triangle. The fire is started and the even rate of spread from the center in all directions is pointed out. The instructor asks for questions and answers them but does not become involved in other principles at this time. Handling

these is planned for subsequent lessons. The instructor does not even put the fire out. He simply moves his class away from the area and his fire stopper steps in behind and mops up. If trainees are permitted to observe the suppression action, they will think about other things instead of the basic lesson at hand. Next, a trainee repeats the process with his own small fire and explanation. A critique completes lesson one.

The second lesson could demonstrate the effect of different fuel types or different fuel density on the rate of spread. An actual fire is used to show how heavier or sparser fuels affect its spread. No doubt the instructor will have to prepare his fuels a bit so that the principle can be adequately demonstrated under simple conditions. Slope, wind, and other factors should remain unchanged and should not affect the demonstration. Only one principle should be stressed. After questions have been answered, the group moves away from the fire. And again a trainee, preferably a different one, prepares similar conditions, lights his fire, and proceeds with a full explanation and demonstration of the principle involved. The critique completes the lesson.

Additional lessons in fire behavior follow, but each successive lesson stresses only one basic principle. Points which have been previously covered may be referred to as they relate to a current lesson, but principles reserved for future lessons should not be discussed until their time. Wind, slope, and fuel moisture can be covered in whichever order the instructor prefers. Sometimes windy conditions in the field will make it difficult to isolate this factor, but at least its influence can be seen and explained. Our experience has been that a good instructor can handle such unforeseen occurrences without excessive trouble. If the day is calm, wind can be generated by a portable fan and battery.

It is important that each trainee gets several opportunities to participate actively in both demonstration and explanation. This method of instruction with trainee participation is basically similar to the four-step method:

1. Instructor outlines the conditions and the lesson to be learned.
2. Instructor starts his fire and explains the key point.
3. Trainee presents similar conditions, starts his own fire, and explains the key point.
4. Follow-up is accomplished back on the ranger district as employee puts training into practice on going fires.

After the class has covered the basic points of fire behavior, the instructor proceeds, one point at a time, through the principles of line location. He explains how the various principles of fire behavior just learned affect the location of firelines. The presence of natural barriers, heavy or flash fuel, the proximity of slope, the problem of a fire just starting up both sides of a draw, and the effect of rolling material on a slope are just a few of the factors influencing line location that can be demonstrated by small fires.

The demonstrator should actually build what line is necessary, while the instructor explains the theory of a particular piece of

line location but does not mention line building techniques. As lessons in line location progress, larger fires may be necessary so that realistic conditions can be had. Nevertheless, for each lesson a trainee should be required to move to a new spot (already picked out for proper conditions), light a new fire, and thoroughly explain the principle involved. He should use the demonstrator for actual line building just as the instructor did. And, of course, a critique is still necessary to conclude the lesson.

After several lessons in line location, the class may progress to the methods of line construction. As successive lessons are introduced the four-step method of instruction is adjusted somewhat in order that all trainees may participate in each line construction problem. Trainee activity is very closely supervised in these lessons since the demonstrator is able to spend part of his time assisting the instructor in the correction of unsound work methods. Fires are permitted to become larger now and the instructor is teaching basic points of the one-lick, progressive, and leap frog methods of line construction. Since trainees have been introduced to the use of basic tools in a previous course, line construction lessons move along fairly rapidly with plenty of fire and lots of smoke. Mopup work is still done by the fire stopper who may now have a small tanker at his disposal, but all trainees work on the control line.

By now trainees are beginning to perspire and they may even develop a smoke eater's cough. Small groups and many fires have made possible an understanding never before reached by spectator training.

The instructor has now had a couple of days to size up his crew and to determine how much more training they can take and at what speed. Principles of initial attack and mopup are still to come. Perhaps several major points can now be stressed in each lesson. Perhaps even more flexibility can be introduced into the mechanics of the four-step method of instruction. The course is brought to an end with two or three one-man fires of good size on which everybody mops up after initial control has been achieved.

Three days are really not enough for this type of course. Four or five days would probably be sufficient but are seldom available. Nevertheless, we feel that three days of instruction as described herein buys a lot more trainee understanding than three days of classroom theory and a moderate amount of spectator training.

Every reader knows, of course, that the success or failure of the "Fire Control Practices" course rests almost entirely on the caliber of the instructor, because of the large number of critical points involved. The very nature of the course requires that one instructor and one demonstrator stay with the class for the full time. They can maintain the continuity of the course and at the same time use as valuable training aids questions and happenings that occur. Then, too, instruction will be far more effective if the teacher is able to adjust the speed of instruction to the learning capabilities of his group. Such adjustment is impossible when instructors are changed during the course.

The "Fire Control Practices" technique of instruction is hard on teachers. A great deal more time is required for adequate preparation and instruction than would be required of any instructor under the system of larger classes and divided teaching responsibility. And adequate preparation for instruction is essential. The Tahoe has discovered that a thorough field briefing and demonstration period for instructors is necessary. The thinking required in the point by point development of the course can present problems. For example, we find that instructors not thoroughly briefed in the theory of the course have difficulty in moving their groups away from a going fire to let the fire stopper move in and finish the job.

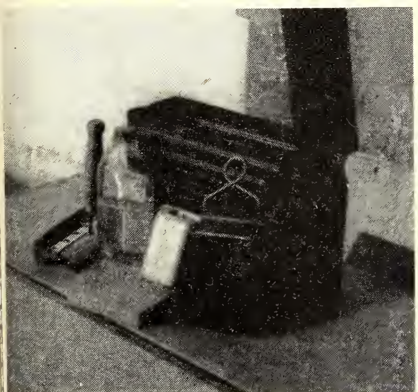
We have found that one short day is not enough for this preparatory meeting. Perhaps one long day or two short days would do the job. We think that this amount of time is justified. If the program is retained over the years and if the theory of the course is accepted throughout the ranks, perhaps such an intensive preparatory meeting will become unnecessary.

In addition to this preliminary get-together on theory and techniques, instructors must look over their demonstration area ahead of time so as to determine which spots should be used for which lessons. Considerable picking and choosing is necessary and the job cannot be done in a few minutes. Quite possibly an instructor will want to mark his planned route of travel with string, and he may even want to leave notes for himself at the many spots he has chosen for his various lessons. The string is helpful to a checker who will make a final inspection of all fires a day or two after the training session.

☆ ☆ ☆

Compact Cleaning Kit For Lookout Cabs

A standard ammunition box (Cal 30 M) is a very satisfactory storage container for the cleaning materials necessary for good tower-cab housekeeping (fig. 1). This 4- by 8- by 12-inch metal container, with a close sealing cover, is available at surplus stores for about 50 cents. The following items fit neatly into the box and are recommended for the essential cleaning jobs: "Squeegee" cleaner with wiping blade in combination, 6-inch width; bottle of nonflammable cleaner fluid, 8 to 10 ounces; whisk broom, 6- to 8-inch length; cellulose sponge, 4 by 6 inches; soap in tin or plastic box; 2 cleaning cloths.—LLOYD MAKI, *Forest Fire Officer, Michigan Department of Conservation.*



VARIATIONS IN BACKFIRING IN THE SOUTH

R. J. RIEBOLD
Forest Supervisor, South Carolina National Forests

When large-scale fire protection in the Southeast began about 1933, grass fires in 1-year roughs on cutover longleaf land were whipped out with pine tops or swatters. As fire protection succeeded, pine reproduction came in and dense stands of seedlings and saplings were formed over large areas. By 1943 the growth of reproduction had been accompanied by the growth of a dense hardwood understory and the accumulation of deep layers of pine needle fuels, often draped head high on the understory brush. Accumulation of light flash fuels alone amounted to 10 to 20 tons per acre *(4)*.[1] These conditions led to prescribed burning for fuel reduction and hardwood control *(1, 2, 7)*. In combination with other factors, they also led to the development and widespread use of the tractor-plow outfit *(5, 6)*. Standard practice today in the Coastal Plain forests is generally to stop the forward movement of the head of a fire by plowing a line in front of it, backfiring, and holding the plowed line. The control line is located far enough in advance of the fire so that the backfire and the head fire meet 25 to 50 feet from the control line. Ordinarily, little difficulty is experienced in holding the line.

When burning conditions become severe, however, surface fires burn harder and crown occasionally. Exceptionally dry conditions are sometimes coupled with erratic fire behavior. Speaking of conditions on the Francis Marion National Forest in South Carolina in 1950, Byram and Nelson *(3)* said: "It should be emphasized again that the changing fuel and stand types occurring in the Southeast may be a necessary condition for the large whirling fires which burned in South Carolina last year. These fires burned in dense stands of reproduction (predominantly loblolly pine) in which the compact crowns constituted the main source of fuel. In turn, the availability of this green fuel for combustion was increased by an unstable atmosphere plus a high rate of energy release in the ground fuels."

Under severe burning conditions the commonly used single backfire set from the control line fails in many cases to hold the head fires. The usual meeting place of head fire and backfire is too close to the control line. With backfires moving at the rate of about 1 chain per hour and head fires advancing at rates of 1 to 4 miles per hour, there is simply not time enough for the width of the burned out strip to be increased sufficiently merely by the burning of the backfire away from the control line. The need to increase this width, to place the meeting of head fire and backfire farther from the control line, has led fire control men to devise variations in backfiring practice. Those described here have been used on the Francis Marion National Forest. Probably similar variations have been developed on other fire control units throughout the South.

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[1] Italic numbers in parentheses refer to Literature Cited, p. 33.

One variation is termed "parallel backfiring." Instead of ıerely firing along the control line, an additional line of backfire s set between the head fire and the control line and roughly ›arallel to it. The first torchman works 50 to 100 feet from the ontrol line and between it and the head fire. The second torchman ires the control line about 100 feet behind the first torchman, or lose enough to keep the interior backfire from sweeping up to the ontrol line and crossing it. Both men move in the same direction. 'his method puts the meeting place of head fire and backfire about wice as far from the control line as the usual practice does. It ends to reduce the heat and smoke along the control line because he two backfires draw together.

A second variation, called "delaying backfire," is similar to ›arallel backfiring. Its purpose is the same: to cause a crowning ead fire to stop for lack of fuel at a greater and safer distance rom the control line. The delaying backfire is set 5 to 20 chains rom the control line instead of 50 to 100 feet as in parallel back-ıring. The method of firing is the same. The control line is fired n the usual manner to hold the leeward edge of the delaying back-ıre, which, in the distance indicated, may acquire considerable olume and velocity.

Another variation, also intended to break the forward move-ıent of the head of a fire, is "perpendicular backfiring." Two orchmen, 100 feet to 100 yards apart, move out from the place on he control line where the center of the head will probably hit and et backfire squarely into the wind toward the head of the fire. Vhen they have gone as far toward the head of the fire as they afely can, they turn away from each other and return to the con-rol line along the flanks of their backfires. The control line is ired in the ordinary manner. The two strips of backfire, advanc-ng and spreading, break up the head of the fire at a good distance rom the control line.

The movement of men setting backfires between the control ine and the head of the fire is, of course, hazardous. Such work is o be undertaken only by experienced men, directed by experienced ire bosses, and supported by well-trained, well-organized crews. The woods must be fairly open and free from brush so the men an see and move. A great deal of danger is always present when ıen are in front of crown fires or fast moving surface fires. A rew of men strung out along a singly fired line in front of a head ire is placed in greater jeopardy than is usually realized. The ›urned out strip is necessarily shallow and the meeting of the ›ackfire with the head fire may take place close to the line. The ıen are subjected to great heat and possibly flames. There is con-iderable likelihood that the woods behind them will ignite and heir escape routes be closed. Backfiring methods which stop the ıead fire at a greater distance from the manned control line actual-y increase the safety of the men holding the line.

The meeting of head fire and backfire causes a tremendous ıpdraft of heat and flame, which often result in a strip of complete ill, even when the head fire alone is not hot enough to do so. Sev-

eral variations in backfiring have been employed or suggested to eliminate this belt of severe damage. The commonest is to use a road as the fireline and let the head fire come up to the road without backfiring at all. Since the clearing widths for most State county and national-forest roads is from 30 to 80 feet, this "width of no fuel" is often sufficient. When it is not, Forester John T Hills, Jr., who has had many years of fire suppression experience on the Francis Marion, suggests that the width of no fuel can be increased by plowing a line and burning out a 50 or 60 foot strip on the side of the road away from the fire. The added width would give the same effect as a backfire burned out 100 to 150 feet from the control line. However, the head fire would burn up to the road instead of meeting a backfire, and, consequently, no strip of severe damage would occur.

The same result has been obtained with two plowed lines. If two tractor plows are available, paralleling lines 100 feet to 100 yards apart are plowed in front of the head fire. Instead of backfiring the inner line toward the head fire, the space between the two plowed lines is burned out in strips as in prescribed burning. The head fire burns up to the area of no fuel and stops. There is no moving backfire for it to meet and, again, no strip of complete kill occurs.

Pond pine and titi bays throughout the longleaf-loblolly pine stands create special backfiring problems. Most of the time tractor-plow outfits cannot cross the bays, and control lines must be cut around them. In dry times the bays can be plowed but backfiring in the dense undergrowth is hazardous even on the flanks and rear of a fire. Because prescribed burning for fuel reduction cannot be used in the bays, they may have a 20-year fuel accumulation. Rate of spread of the backfire may be slow and the burn-out incomplete, but a shift of the wind can cause both crew and plow to be trapped in an area of heavy brush and heavy fuel.

To deal with such a condition, Fire Control Aid James Parker used the following method. He sent the tractor-plow about 15 yards into the bay without plowing, merely breaking down brush. He then had it turn and plow out on the same line, returning to a safe place on the edge of the bay. About 100 yards of this line was backfired. When the backfire had burned out to a safe distance from the line, he sent the plow in again to repeat the maneuver. Each time, the plow returned to a safely burned out part of the line before the line ahead was backfired. The tractor-plow was thus not at any time at the end of a plow line in very thick brush while a long line of backfire was being set behind it. This method requires time and is not suited to stopping a fast-moving head fire. It does provide greater safety for men and equipment in an area of high hazard.

The successful execution of these variations in backfiring requires not only boldness and skill on the part of the men but a higher degree of organization, training, and discipline on the part of the whole attack force than is generally found in hastily mobilized crews of untrained volunteers.

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Where there have been accidents, demerol has relieved pain and stopped a lot of suffering. Use demerol only when pain is severe and immediate relief not available. Never use it for skull fractures or illness. Avoid freezing and demerol will last indefinitely.

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IMPORTANT: ALWAYS HOLD GLASS VIAL IN "BOTTOMS-UP" POSITION ABOVE NEEDLE WHEN ADMINISTERING. (The liquid is forced out by compressed gas. *If not bottoms-up, gas will escape without forcing out liquid.*)

1. After thoroughly cleansing the injection area with soap and water, alcohol, or other disinfectant, grasp hub of needle between the thumb and index finger.
2. Remove needle cover by twisting.
3. Insert needle into body in almost any place. Preferred spots are muscles of upper arm, thigh, calf, buttocks, abdomen.
4. Squeeze before injecting fluid by flattening rubber tube just above needle hub, then release tube. If needle unfortunately strikes a vein, blood will show at top of needle hub and needle must be inserted again.
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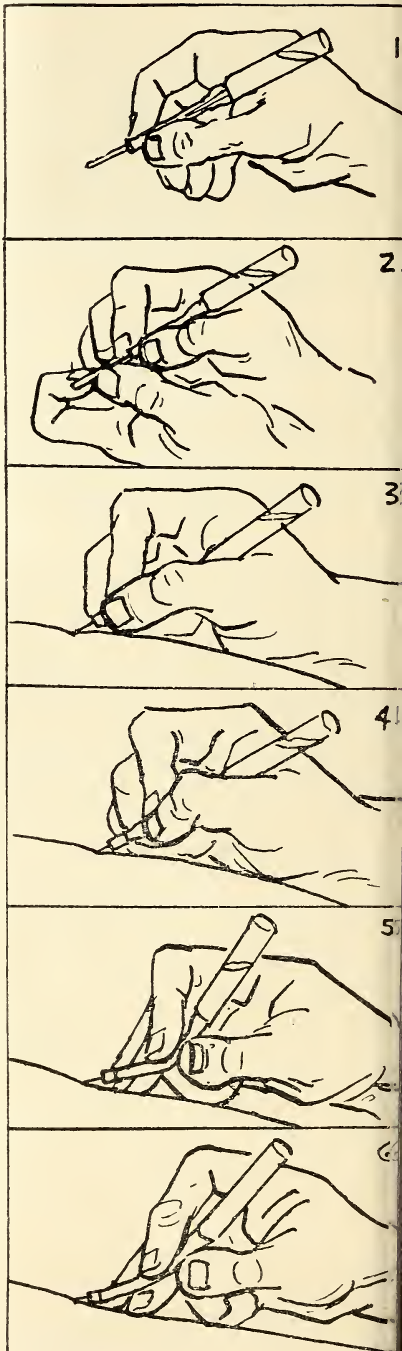

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Remember—Only you can

PREVENT FOREST FIRES!

VOL. 17 OCTOBER 1956 No. 4

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 17 Number 4

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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Forest Service, Washington, D. C.

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CONTENTS

FIRE HAZARD RESULTING FROM JACK PINE SLASH[1]

D. E. Williams

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INTRODUCTION

The accumulation of slash during logging operations introluces a serious problem to those concerned with fire control. Not nly are fires more likely to start in slash areas but once ignited hey have a greater resistance to control and often do more lamage than fires burning in an uncut forest. Slash is treated n a number of ways depending usually on the cutting method. Essentially, there are two main treatments—leaving the slash n the cut-over area, or removing it by burning. Further, the nanner in which the slash is left has an effect on the subsequent ire hazard.

The comparative fire hazard of areas of burned and unburned lash was investigated by Munger and Matthews (*6*)[2] and they oncluded that unburned slash in western Washington and Oregon is one-third more hazardous than burned slash 10 years after ogging. Cheyney (*2*), on the other hand, writes in the Journal f Forestry: "It would be a conservative statement to say that o slash is a special fire hazard in the Lake States for more than years after it is cut." There appears to be no doubt, however, hat an accumulation of slash in a cut-over forest will increase he fire hazard of the area for a considerable period after cutting perations have been completed. Further, it is evident that in ny locality the increase of hazard brought about by the presnce of slash will vary somewhat with the method of slash treatnent employed, and with the number of years which have lapsed since cutting took place.

The Federal Forestry Branch, in co-operation with the Manioba Forest Service, conducted a series of large-scale test fires n slash areas in the Sandilands Forest Reserve. The object of he study was to determine experimentally, (a) the comparative ire hazard in jack pine in similar cut-over areas where different lash treatments had been employed and, (b) the variations in azard which occur as slash ages. The term "slash age" will be sed to refer to the number of years since logging.

This study also provided an opportunity for an investigation f the effect of slash disposal methods on jack pine regeneration. The results of this investigation are described by H. J. Johnson n a current publication of the Federal Forestry Branch (*4*).

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[1]An article of this title appeared in its entirety in 1955 as Forest Research Division Technical Note 22 of the Forestry Branch of the Canada Department of Northern Affairs and National Resources, Ottawa. A somewhat shortened version is published here through the courtesy of the uthor and the Forestry Branch.

[2]Italic numbers in parentheses refer to a list of References, p. 8.

Description of Area

The Sandilands Forest Reserve lies near the southeast corner of Manitoba at the western extremity of Halliday's (*3*) Great Lakes-St. Lawrence Forest Region. The topography is flat and the soil is sandy. Stands of jack pine (*Pinus banksiana* Lamb.) the most important commercial species in the area, are typically very open and consequent heavy branching results in moderate to heavy slash accumulation during logging operations. High underbrush is very scattered and other vegetation is moderate with bearberry (*Arctostaphylos uva-ursi*), blueberry (*Vaccinium* spp.) and caribou moss (*Cladonia* spp.) as the main components along with a considerable amount of grass.

The area in which the study was made is adjacent to agricultural land and is subject to fires started by land clearing operations. Owing to the lack of natural water supplies and to the nature of the soil, fire suppression is best effected by hand tools and pumper-tankers.

The cutting methods which had been employed were mainly medium to heavy selection cuts and a few clear cuts.

Method of Study

Examples of 6 different slash treatments were available in the Sandilands area, and areas representing 4 stages of slash deterioration were located. Duplicate test fire plots were placed within each slash age-class for each type of disposal method wherever it was possible. Table 1 shows the distribution of plots which were available and on which the conclusion of this study was based. In addition to the plots listed, two control plots were located in a representative uncut jack pine stand.

The sample plots were square, 100 feet to the side. Two single furrows were plowed around the perimeter of each plot as a fireguard and, where slash was particularly heavy, an additional fireguard was plowed approximately 20 feet outside the first. A Manitoba Forest Service fire ranger and five or more men were present at all tests and, when the plots had been burned hand tools and pack tanks were used to extinguish the fires.

Four-foot stakes were set at 20-foot intervals throughout the plot providing a grid which greatly facilitated the plotting of the fire perimeter as burning progressed. Just before burning each plot was inspected and a complete plot description was recorded on specially prepared forms. Particular attention was paid to the height of the slash; ground vegetation; kind, amount and depth of duff; and the thickness of the humus layer. The number of pieces and sizes of the heavier fuels (3 inches or more at the large end) were recorded.

Air temperature and relative humidity were measured with a sling psychrometer, and other weather conditions were noted. The wind velocity at the time of the fire was measured with a portable anemometer and its direction was estimated with the aid of a box compass. The amount of dew which formed the

TABLE 1.—*Distribution of test fire plots according to slash treatment and slash age class*

Slash treatment	Plots burned when slash age class was—			
	1-2 years	3-5 years	6-9 years	10-12 years
	Number	*Number*	*Number*	*Number*
eft as cut (untreated)	2	2	2	1
iled and left unburned	1	2	2	2
iled and burned (100 percent)	1	2	2	2
ops only (stands with clear-boled trees)	1	2	2	0
opped and scattered (maximum depth 18 inches)	1	2	2	2
Vindrows (1 chain apart, unburned)[1]	0	2	0	0

[1]This treatment dropped from study because of insufficient data.

revious night was measured by the method developed by the 'ederal Forestry Branch (7) and recorded in the field notes.

Various sizes of branches, duff, and other fuels were sampled nd their moisture content determined by laboratory methods.

Immediately after igniting each test fire, an observer and an ssistant began plotting the position of the fire perimeter at 1- r 2- minute intervals depending on the rapidity of spread.)bservers worked independently on the leeward and windward ides of the starting point and were able to keep accurate records f the fire's progress with the aid of stop watches and guide takes. Notes were made also on the height of flame, vigour, mouldering, and depth of ash.

When the fire was out, further notes on the severity of the urn were made. Estimates were made of the percentage of the rea left unburned as well as the percentages of each type of nburned fuel.

The careful plotting of the fire perimeter at regular intervals ave a very comprehensive picture of the fire's progress and a ıeasure of its rate of spread. The grids were planimetered and he proportionate area burned during each 5-minute interval of he fire's progress was determined.

A numerical hazard index was computed for each test fire, sing much the same method as that employed regularly by he Forestry Branch in rating small-scale test fires (5). In calulating this hazard index the factors used and the relative 'eights given to each were as follows: (1) rate of spread, 30 ercent; (2) total area burned, 20; (3) vigour, 20; (4) height f flame, 10; (5) smouldering, 10; (6) depth of ash, 10. These actors, with the exception of vigour and smouldering, can be ıeasured directly with the result that errors owing to personal udgment are kept to a minimum.

Following the described procedure, all test fire plots show in table 1 were burned during the summer periods of 1949, 1951 and 1952. A fire weather station was set up in the area and th danger index was calculated daily, throughout the periods o the tests, from the Midwest Fire Danger Tables (*1*). All test were made when this local danger index was in the range 7 t 12; the average for all tests was found to be 9.

Each test fire was given a hazard rating as determined b the six performance factors listed above. An adjustment of on hazard index unit was made to the rated hazard for those test made on days when the local danger index differed from th mean by two units or more. For example, one plot was burne on a day when the local danger index was 7. To adjust for th lower fire danger conditions on this day, the rated hazard inde for that test fire, calculated to be 11, was increased by one uni to 12.

It should be noted here that the local danger index refer to the average fire danger in all fuel types in the area, wherea the rated hazard index is a measure of the fire hazard as indicate by the individual test fires in the fuel concerned.

Analysis of Data

Burned slash.—Analysis of test fire behaviour in cut-ove areas where slash had been piled and burned indicated that th hazard is substantially lower than in areas where the slas had been left unburned. Further, it was found that, when slas is burned after cutting operations, the fire hazard can be expecte either to be similar to that existing before the area was cut o slightly higher because of increased insolation. Other investigato have found that, under full insolation, fuel temperatures approach ing 150° F. are not uncommon.

The conclusions drawn here will hold true only if the slas burning operations have been thoroughly carried out, in whic case all the slash in the piles will have been destroyed. It is to b expected, however, that in some instances the original duff an litter will be left unburned between the piles.

Of the test plots burned in this group, one was not include in the analysis. The plot description indicates that there wa an 85 percent coverage of jack pine duff and litter on the pl as opposed to an average of less than 10 percent on the remainin 6 plots representing this treatment. The depth of litter an humus on that was double the average of the other plots. Th was, no doubt, a result of the unusually high density of th residual stand. Observations made on this plot, therefore, we excluded from the analysis on the basis that fuel conditions we not typical.

Figure 1 shows the comparative hazard to be expected wit each type of slash treatment studied and with slash age. Th curve for piled and burned slash (fig. 1) describes the haza of burned slash over the years since it was cut. This curve show that, if slash burning is done thoroughly, the hazard will b almost nonexistent immediately afterward and will increas

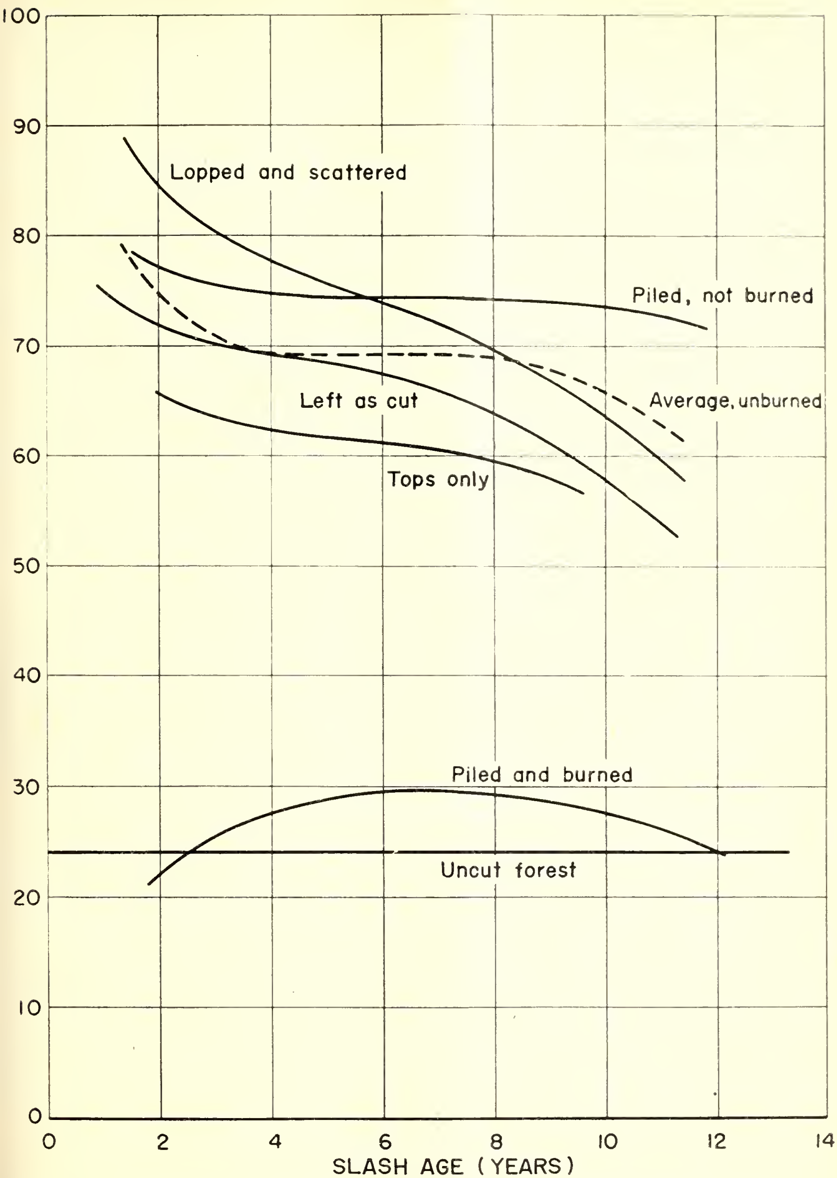

FIGURE 1.—Variation in hazard with age of slash.

within a period influenced by the density of the residual stand and the growth of new vegetation, to a value comparable to that in the uncut stand.

Unburned slash.—The analyses of tests on unburned slash showed that fire hazard will remain comparatively high, regardless of treatment, for at least 10 years after the cut. Figure 1

shows the percent of worst possible[3] hazard to be expecte with each disposal method. These methods are listed in decreas ing hazard potential at a slash age of approximately 2 years (1) Lopped and scattered; (2) piled and not burned; (3) lef as cut; (4) tops only.

Differences in hazard owing to the use of different treatment of unburned slash, however, were found to be small and of littl significance. Of somewhat greater significance is the fact tha slash which has been lopped and scattered or left as cut deter orates more rapidly over the years than that which has bee piled and left. Thus the hazard existing in cut-over areas wher the slash has been scattered or left strewn about, althoug initially high, falls off with age at a relatively rapid rate.

On areas where tops only have been left after cutting, th hazard is lower than when other treatments have been employe and the reduction in hazard over the years parallels closely tha for piled slash. It should be borne in mind, however, that in th Sandilands area stands are typically open, and this type of slas consists mainly of scattered tops. Where this treatment is use in heavy stands the tops are more or less contiguous and th slash resembles that left as cut.

Of the test fires made in slash which had been piled an left, only 6 of the 7 fires were considered to be truly representativ of normal conditions. A changing wind direction during th course of the burning of one plot prevented the fire from burnin consistently on any one front. Also, there were more bare patche on this plot than were normally encountered on the remainin six plots. In consequence, observations made on that plot wer not included in the analysis.

The average height of the piled slash was 3 feet and when th test fire was in progress, sufficient heat was produced by th burning piles of slash to promote the rapid spread of the fir between the piles. This was normally a distance of 20 feet. Unde the piles, all duff and organic matter was completely burned t mineral soil, whereas between piles the burn was light. Ther was less falling off of hazard with slash age than occurred whe the lopped-and-scattered or left-as-cut methods were employe

In almost all areas of piled slash and tops only, there wer sufficient surface fuels to allow the fire to run from pile to pil or from top to top.

Conclusions

In the region and season in which these tests were made, th burning of jack pine slash, when thoroughly carried out, wi reduce the fire hazard to a level comparable to that of the uncu forest and to about one-third of that of unburned slash. Ther fore, where hazard reduction is of primary importance, seriou consideration should be given to slash burning after cuttin

[3] "Worst possible" refers to the highest hazard rating based on tl 0 to 16 danger index scale.

operations. This is the only commonly used slash disposal method which is effective in reducing the fire hazard.

The hazard resulting from unburned slash is comparatively high for at least 10 years after it has been cut; about 3 times as great as the hazard of the uncut forest. Some further effects regarding unburned slash were noted in this study: (a) The hazard is highest immediately following the cut when the dead foliage is still clinging to the twigs. (b) The hazard diminishes gradually as the needles dry and fall—that is, until approximately 4 years after the slash has been cut. (c) From this point until the slash is 8 or 9 years old, the hazard decreases slowly as the debris weathers and compacts. (d) After this time the slash has been reduced by weathering and other action to a point where it is overgrown by an increasing abundance of vegetation. With this increased shade, the slash receives less ventilation and solar radiation and, as a result, the rate of moisture loss is reduced, thus further lessening the hazard.

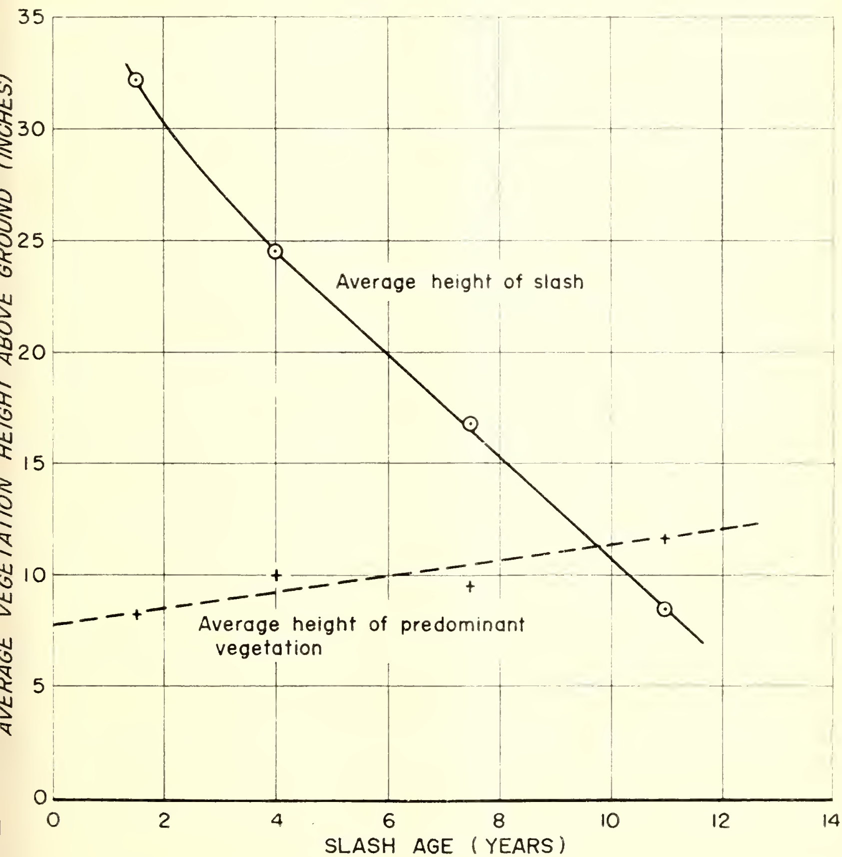

FIGURE 2.—Deterioration of unburned slash with age, and growth of ground vegetation after cut.

An illustration of this process is given in figure 2. The curves show the relationship between average height of slash and height of ground vegetation during the first 12 years following the cut. From this graph it appears that green vegetation begins to overtop the slash 10 years after the cut. Figure 1 shows a general falling-off of fire hazard at approximately this same point. It may be expected that, where environmental conditions differ from those of the area under study, the rate of slash deterioration and vegetative growth may also be different.

The small differences in hazard resulting from the use o the four different treatments of unburned slash are more or les of academic interest only. The choice of one method over anothe will depend a great deal on the chooser's point of view. Fo example, it may be felt that the high initial hazard of slash which has been lopped and scattered or left strewn over an are is offset by the relatively rapid rate of hazard decrease which would obtain with increasing slash age. Others may argue tha this high initial hazard is too risky to tolerate under an circumstance.

Although Johnson (*4*) found that the poorest regeneration resulted from piling and burning, no slash treatment studied gave a satisfactory stocking of seedlings. Thus, because it results in the lowest hazard, the piling and burning of jack pine slash should be carried out whenever it is economical to do so.

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THE CHRISTMAS EVE PRESCRIBED BURN

ALBERT A. THOMAS[1]
East Gulfcoast Research Center, Southern Forest Experiment Station

It was the morning before Christmas, Santa Claus was loading up and the holly and mistletoe were being hung. Gifts were being wrapped, and the weather was just right for prescribed burning on the Escambia Experimental Forest. The south Alabama woods were damp, the north wind was swaying the tree tops, and the air temperature was near freezing. This was the weather the Escambia foresters had wanted for nearly 2 months. Brown-spot needle disease had invaded several large areas of longleaf reproduction on the forest. The only practical way to save the infected seedlings was to prescribe-burn, and this was the day for the job. Seven years of study and experience went into the planning and application of the Christmas Eve burn (fig. 1).

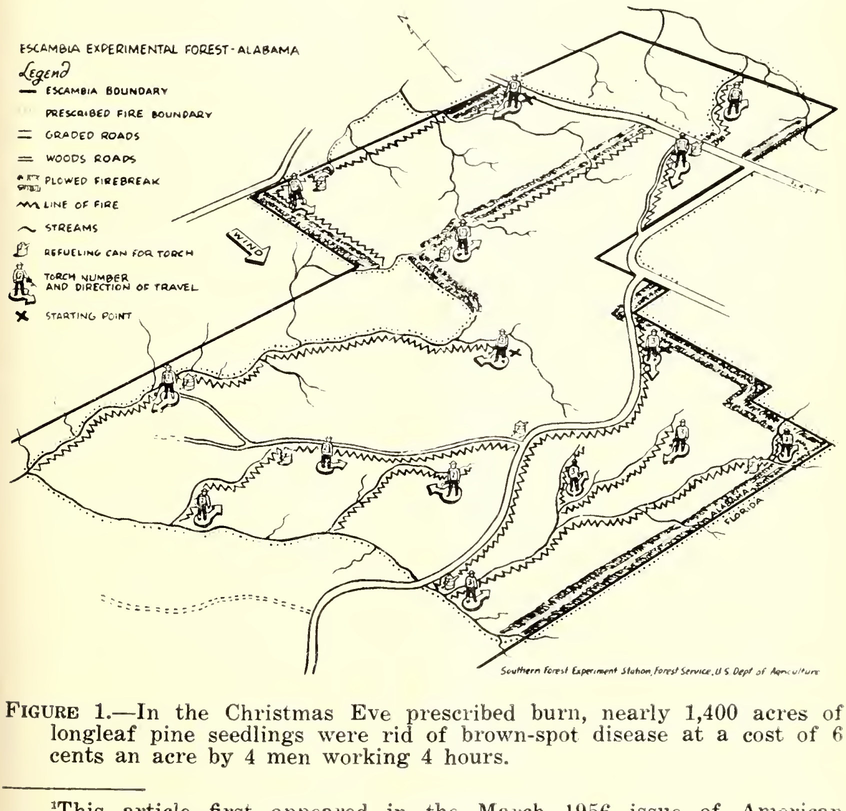

FIGURE 1.—In the Christmas Eve prescribed burn, nearly 1,400 acres of longleaf pine seedlings were rid of brown-spot disease at a cost of 6 cents an acre by 4 men working 4 hours.

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[1]This article first appeared in the March 1956 issue of American Forests and is republished here through courtesy of that periodical.

Prescribed burning is a calculated risk. The risk should be taken only after careful planning and preparation based on a thorough understanding of fire and fire behavior. The guiding principle for prescribed burning on the Escambia is **the burning yardstick.**

The **yardstick** is simple. **Benefits** from the fire must **exceed** all burning **cost plus** fire **damages.** Application is more complex. A five-step procedure is used: **diagnosis, prescription, preparation, treatment,** and **appraisal.** When properly followed this procedure removes most of the gamble, and fire becomes a useful tool in the longleaf forest.

Diagnosis

First, exactly what areas on the forest contained heavy brown-spot infection? What damages could be expected from the use of prescribed fire? To find out, a survey was made. After the first killing frost in early November, the percent of brown-spot infection was estimated on a minimum of 100 longleaf seedlings on each 10- to 40-acre reproduction area.

The survey showed several hundred acres of grass-stage longleaf reproduction infected with brown spot, with the degree of infection ranging from a low of 15 percent to a high of over 35 percent. Past experiments and experience have shown that areas with 25 percent or more infection in November should be prescribe-burned during the coming winter. To prevent reinfection, the area surrounding the seedlings should also be burned where possible.

Longleaf seedlings can generally be burned safely if: (1) they are at least one-half inch in diameter at the root collar; (2) very little root is exposed; and (3) the seedlings are not in active height growth. The survey showed that if fire was applied properly, damage should be confined to a few scattered seedlings 1 to 5 feet high that were already nearly dead from brown spot.

The areas that needed burning were mapped. Then, to plan for control of the fire, information was obtained on the condition of rough, natural fire breaks, roads, and trails.

The diagnosis: Several large areas were dangerously infected. Fire was needed and could be applied without excessive damage.

Prescription

Next was to prescribe the fire treatment for each area—the kind of fire and the weather needed.

If the areas had had a heavy rough and lots of draped fuel, a backfire would have been prescribed. Heavy roughs with draped fuel burn very hot, and unnecessary overhead scorch to standing timber would occur if headfire were used. The survey showed, however, that the areas contained a light rough—a small accumulation of pine straw and not much grass. A fast-running headfire would be safe and do a better job than a backfire.

Weather is the most important factor in prescribed burning. Cold weather and plenty of ground moisture are essential. This means burning in winter as soon as possible after 1 inch or more of rainfall. To get a fast-moving headfire, a moderate, cold north wind is needed—north wind because it is usually dependable and steady in south Alabama. To insure that all areas will be covered while ideal weather lasts, fires should be started by 10:00 a. m. and be completely under way by noon.

The prescription: A headfire on a day when ground moisture was plentiful and a moderate, steady, cold north wind was blowing. The fire to be under way before noon and to cover the areas in a few hours.

Preparation

Successful burning can only be done after thorough preparations for applying and controlling the fire.

In delineating each area to burn, natural firebreaks such as roads and streams were used wherever possible, to save firebreak contruction. Nearby landowners were contacted. Letting neighbors know what's going on is always good public relations, and on the Christmas Eve Burn permission was needed to burn two areas into natural firebreaks outside the forest boundary. This saved more than one-half mile of firebreak construction, and eliminated two heavily infected areas adjoining the forest.

Since the prescription called for headfire and a north wind, 2 lines about 100 feet apart were plowed and burned on the south, east, and west boundaries to control the fire where natural firebreaks were not available. On the north side of the area only a single plowed line was necessary.

Next, was to be sure a headfire would be under way in all areas by noon of D-day, and that burning would be completed a few hours later. The map showed that one line of fire along the north boundary would have to travel more than a mile. This is too far. Experience has shown that one-half mile is about the maximum for the time allowed in the prescription. Otherwise, the burn may not be completed before weather conditions change. Another east-west firing line was therefore put in. Natural firebreaks could be used to fire the rest of the area.

A total of 9 miles of line had to be fired. One torch man would be able to fire about 3 miles in the allotted 2 hours between 10:00 a. m. and noon. The line was roughly divided into 3-mile sections and assigned to men designated as Torches 1, 2, and 3. Since 1-gallon fire torches hold only enough fuel for about three-fourths of a mile of line, refueling cans would be needed at intervals along the line. A small letter-size map was prepared to show each torch man (1) the line to fire, (2) the direction of travel, (3) locations of refueling cans, and (4) how to fire his part of the line. A crew of 3 torch men and 1 man supervising and patrolling the burning area was required.

By early November everything was ready except the most important item, the weather.

Treatment

It was the day before Christmas, Santa Claus was busy with his myriad preparations for his trip that night, but the weathe was just what the doctor ordered for prescribed burning. Ther had been almost 3 inches of rainfall in the past 3 days. Ai temperature was down to 29°F. A cold front was overhead an a moderate, steady, north wind was blowing. The Weathe Bureau predicted that this condition would last for 10 to 1 hours.

Early morning telephone calls were made ordering the cre to get into their "burning" clothes. The Alabama and Florid forestry departments were notified to expect a big smoke startin at 10 o'clock. Torch fuel was distributed to the planned point along the burning lines. At 9:30 a. m. the crew met on the forest A small test fire was set and then each torch man was briefe and given his map. At exactly 10 o'clock all three torches starte firing. A few minutes after 12 noon all torches were through an well over half of the area was burned. At 2 o'clock over 9 percent of the area was burned. By 3 o'clock the crew, tired bu satisfied, was back home helping Santa Claus.

Appraisal

What were the benefits? Longleaf experts agree that a heav infection of brown spot can ruin a stand of seedlings. The estab lished seedlings treated by the Christmas Eve Burn were wort at least $4,000. It is doubtful that half of these would hav survived and grown without the prescribed fire. At least $2,00 worth of seedlings were saved.

What was the cost? The whole job, including diagnosis, pre scription, preparation, treatment, and appraisal, came to les than $100.

What were the damages? A seedling survey after the fir showed less than 1 percent loss in stocking—a value of not mor than $50. Most of the lost seedlings were stunted and heavil infected with brown spot and probably would have died anyway Their value was more than offset by many fringe benefits, suc as hardwood brush control, seedbed preparation, hazard reductio and a large area burned to prevent reinfection of the reproductio areas.

The **burning yardstick showed** that the **benefits** of severa thousand dollars in brown-spot control far **exceeded** the burnin **cost plus** the minor **damages** of the fire.

A READY-REFERENCE RADIO DISPATCH BOARD

George W. Dean
State Forester, Virginia

The large number of mobile and tower radios now in service with the Virginia Division of Forestry made it necessary to find a simple record system that would expedite the clerk-dispatcher's job of keeping track of the frequent changes in location and activities of men in the field. One district forester devised such a system from a piece of acoustical tile and roofing nails, and with a minimum number of changes the unit was workable statewide.

The ready-reference board is made of ¾-inch plywood 14 inches wide, and it is 14 inches or more in height (fig. 1), depending upon the number of radios in use. Holes are bored on ½-inch centers large enough to accommodate 8-penny, double-headed nails. Since the entire length of nail is not necessary, it is cut

Figure 1.—The ready-reference radio dispatch board.

in half. A small, compartment tray, which is screwed to th bottom of the board, serves as a storage bin for the nail pegs The nail pegs are painted red for off-air, green for on-air, and yellow for special messages. The board's vertical columns are headed by counties in the district and major jobs, and one column is headed "Special message." The column to the extreme left lists the mobile or tower units.

When a unit signs on the air, the clerk places a green nai in the hole opposite the name and under the proper county. If the unit is called to a fire, a green nail is added to the horizonta column under the vertical heading "On fire." Should the uni sign off the air to go in on the fire, the clerk replaces the 3 green nails with red ones. If a special message comes in for the off-air unit, a yellow reminder nail is placed in the special messag column. When the unit signs on, the red nails are replaced with green, the special message is given, and the yellow nail is removed.

A large district map—a montage of county maps on which towers are located and provided with azimuth circles and strings—is used to supplement the dispatcher's ready-referenc board (fig. 2). This map is covered with clear plastic, the kind used for inexpensive storm windows. As fires spring up, entrie are made on the plastic with grease pencil, and a note as to who from the district office is on a fire is also entered. Mistake or changes are easily erased with a swipe of a cloth. Of course the ready-reference dispatch board and plastic-covered work ma are valuable only if they are kept up-to-date and supplemente with essential, written or otherwise, posted material.

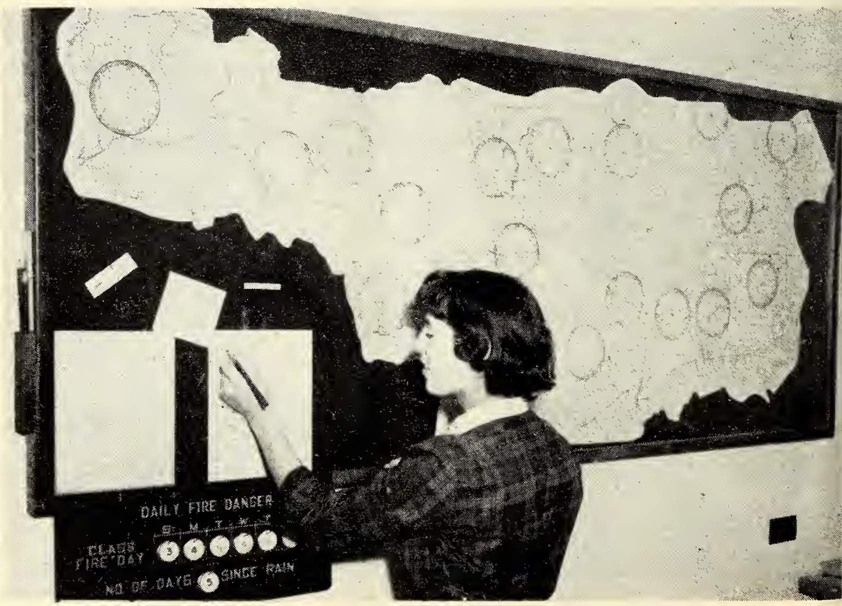

FIGURE 2.—A grease pencil is used to keep information current on th plastic-covered, fire locator map.

OLD-GROWTH CONVERSION ALSO CONVERTS FIRECLIMATE

C. M. COUNTRYMAN

Forester, California Forest and Range Experiment Station[1]

Converting an old-growth forest presents problems that have long challenged foresters, engineers, and economists. Road location, method of cutting, fire control, and slash disposal are all critical jobs. In terms of fire control, the forest manager has been concerned primarily with slash disposal and fire suppression in slash areas. He has frequently observed the great difference in fire behavior between slash and uncut areas, and quite naturally has associated this difference with the obviously different fuel conditions.

Although the general relations between weather factors, fuel moisture, and fire behavior are fairly well known, the importance of these changes following conversion and their combined effect on fire behavior and control is not generally recognized. The term "fireclimate," as used here, designates the environmental conditions of weather and fuel moisture that affect fire behavior. It does not consider fuel created by slash because regardless of what forest managers do with slash, they still have to deal with the new fireclimate. In fact, the changes in wind, temperature, humidity, air structure, and fuel moisture may result in greater changes in fire behavior and size of control job than does the addition of more fuel in the form of slash.

Conversion which opens up the canopy by removal of trees permits freer air movement and more sunlight to reach the ground. The increased solar radiation in turn results in higher temperatures, lower humidity, and lower fuel moisture. The magnitude of these changes can be illustrated by comparing the fireclimate in the open with that in a dense stand. It is the same kind of difference that occurs when a closed, mature stand is clear cut.

In the open, solar radiation impinges directly on the earth's surface. Because both the earth and the air above it are poor conductors, heat is concentrated at the surface and in the layer of air next to it. Ground fuels can thus become superheated. In full sun at midday, it is not uncommon for surface temperatures to reach 165° F. or more.[2] At the same time, air temperatures measured at the standard height of 4½ feet in an instrument

[1]Maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California. This article was first published in the Society of American Foresters' Meeting Proceedings for 1955.

[2]From unpublished data in files of California Forest and Range Experiment Station. Similar findings were also reported by:

GEIGER, RUDOLF. CLIMATE NEAR THE GROUND. (Trans. 2d German ed.) 482 pp., illus. Cambridge, Mass. 1950.

KITTRIDGE, JOSEPH. FOREST INFLUENCES. 394 pp., illus. New York and London. 1948.

shelter may not exceed 85° or 90°. Temperatures in the lower layers of air in the open decrease rapidly with height above the ground. In a typical temperature profile in northern California, for example, the temperature was 135° at the surface and decreased to 77° at 5 feet (fig. 1).

Relative humidity will vary inversely to the temperature of the air as long as the amount of water vapor remains constant. A relative humidity profile, then, can be expected to be the inverse of the temperature profile, and in the open relative humidity near the surface is much lower than that at the standard 4½ feet.

These temperature and humidity relations have an important influence on fuel moisture. In the absence of precipitation, the moisture content of dead fuel decreases as humidity decreases and as temperature increases. Surface fuels can thus be expected to be materially lower in moisture content than fuels a short distance above the ground and exposed to the cooling effect of wind. Measurements of standard half-inch fuel-moisture indicator sticks at the California Forest and Range Experiment Station have shown that the minimum daily moisture content of surface fuels averages only about half that of fuels 10 inches above ground.

A mature, closed stand has a fireclimate strikingly different from that in the open. Here nearly all of the solar radiation is intercepted by the crowns. Some is reflected back to space and the rest is converted to heat and distributed in depth through the crowns. Air within the stand is warmed by contact with the crowns, and the ground fuels are in turn warmed only by contact with the air. The temperature of fuels on the ground thus usually approximates air temperature within the stand.

Temperature profiles in a dense, mixed conifer stand illustrate this process (fig. 2). By 8 o'clock in the morning, air within the crowns had warmed to 68° F. Air temperature near the ground was only 50°. By 10 o'clock temperatures within the crowns had reached 82° and, although the heat had penetrated to lower levels, air near the surface at 77° was still cooler than at any other level. At 2:00 p.m., air temperature within the stand had become virtually uniform at 87°. In the open less than one-half mile away, however, the temperature at the surface of pine litter reached 153° at 2:00 p.m.

Because of the lower temperature and higher humidity, fuels within the closed stand are more moist than those in the open under ordinary weather conditions. Typically, when moisture content is 3 percent in the open, 8 percent can be expected in the stand.

Moisture and temperature differences between open and closed stands have a great effect on both the inception and the behavior of fire. For example, fine fuel at 8-percent moisture content will require nearly one-third more heat for ignition than will the same fuel at 3-percent moisture content. Thus, firebrands that do not contain enough heat to start a fire in a closed stand may readily start one in the open.

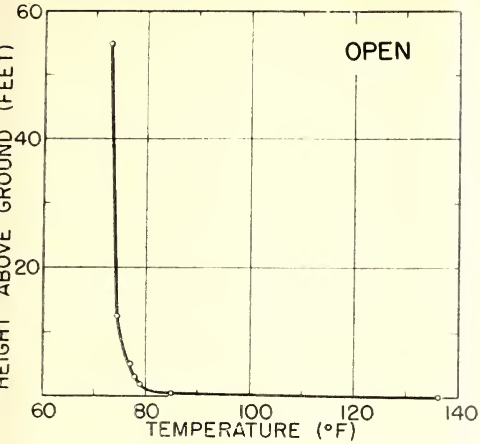

FIGURE 1.—Typical temperature profile over bare ground in the open. (Data taken at 12 a.m., Sept. 16, 1943, Shasta Experimental Forest.)

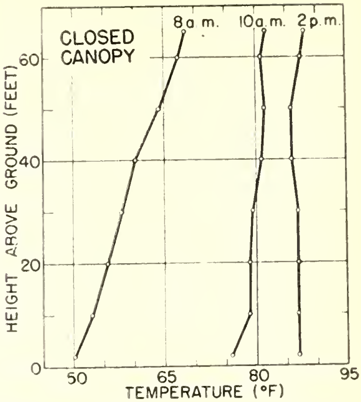

FIGURE 2.—Temperature profiles in a dense, mixed conifer stand in northern California showing the progressive downward transfer of heat into the stand from the crowns. (Data taken Sept. 22, 1943.)

Fires starting in the open also burn more intensely and build up to conflagration proportions more quickly since less of the heat produced by the fire is used in evaporating water from the drier fuels. Strong convection columns that can carry burning material aloft develop rapidly; these columns and the relative ease of ignition in the open are largely responsible for one of the major fire control problems in clear-cut slash areas—that of spread of fire by spotting.

Another very important difference between fireclimate in a closed stand and fireclimate in the open is in air movement. In general, wind direction and velocity 2,000 feet or more above the surface are the result of widespread pressure differences and general weather conditions. In the layer of air below 2,000 feet, surface friction and local landscape features have an increasingly important effect on air movement. Consequently, over an extensive closed stand wind velocity decreases only slightly above the crowns. Within the stand, however, air movement is much restricted, seldom exceeding 3 or 4 m. p. h. even with velocities of 25 to 30 m. p. h. above the canopy or in the open (fig. 3).[3]

Since the rate of forward spread of fire is largely dependent upon wind velocity, a much faster rate can be expected in the open, at least in the initial stages of the fire. For example, under

[3]KITTREDGE, JOSEPH. FOREST INFLUENCES. 394 pp., illus. New York and London. 1948.

FONS, W. L. INFLUENCE OF FOREST COVER ON WIND VELOCITY. Jour. Forestry 38: 481-487, illus. 1940.

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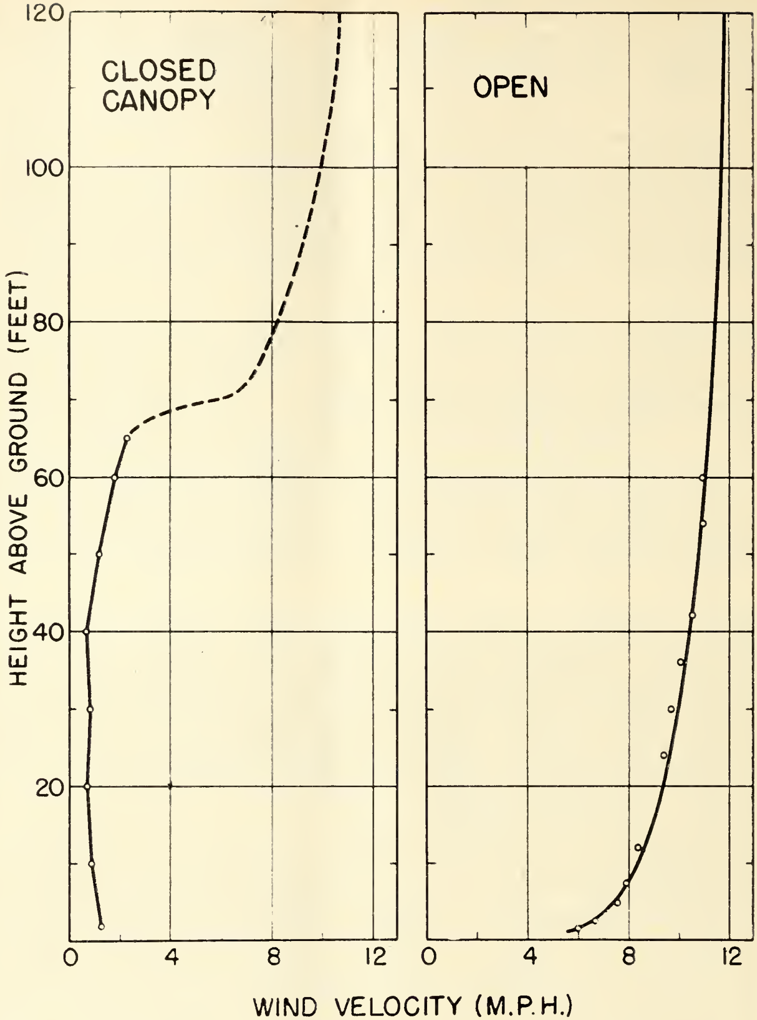

FIGURE 3.—*Left*, Typical daytime wind profile in and over dense conife stand. *Right*, Typical daytime wind profile over level ground in th open.

moderate conditions of fuel moisture and temperature, a win velocity of 25 m. p. h. will result in a rate of spread more tha 5 times as great in the open as in a closed stand because o wind differences alone.

Clear cutting, then, can change fireclimate so that fires star more easily, spread faster, and burn hotter. The effect of thes changes on the fire control problem is extremely important. Whe a standard fire weather station in the open indicates a tempera ture of 85° F., fuel moisture of 4 percent, and a wind velocit of 15 m. p. h.—not unusual burning conditions in the West— fire starting on a moderate slope will spread 4.5 times as fas

in the open as in a closed stand. The size of the suppression job, however, increases even more drastically.

Greater rate of spread and intensity of burning require control lines farther from the actual fire, increasing the length of fireline. Line width also must be increased to contain the hotter fire. Less production per man and delays in getting additional crews complicate the control problem on a fast-moving fire. It has been estimated that the size of the suppression job increases nearly as the square of the rate of forward spread. Thus, fire in the open will require 20 times more suppression effort. In other words, for each man required to control a surface fire in a mature stand burning under these conditions, 20 men will be required if the area is clear cut.

Methods other than clear cutting, of course, may bring a less drastic change in fireclimate. Nevertheless, the change resulting from partial cutting can have important effects on fire. The moderating effect that a dense stand has on the fireclimate usually results in slow-burning fires. Ordinarily, in dense timber only a few days a year have the extreme burning conditions under which surface fires produce heat rapidly enough to carry the fire into the crowns. Partial cutting can increase the severity of the fireclimate enough to materially increase the number of days when disastrous crown fires can occur.

Forest management is impossible without adequate fire control, and it is axiomatic that fire control planning is a vital part of timberland management. It is important to recognize that besides creating additional fire hazard in the form of slash, stand conversion can alter the fireclimate for many years. Therefore, the effect of silvicultural practices on fireclimate must be given major consideration in the management plan for the forest. Protection must be adequate to compensate for the changes in fireclimate as well as for slash. This is the only way to insure that we convert our old-growth forests to managed stands and not to wasteland.

ICE HYDRANT PROVIDES EMERGENCY WINTER WATER SUPPLY FOR FIRE FIGHTERS

Federal Civil Defense Administration[1]

Glen Miller, Civil Defense Fire Chief, Moose Pass, Alaska, has developed an ice hydrant, first of its kind, that can provide an emergency water supply for fire-fighting forces in those communities located near lakes and streams which are frozen over during winter months.

Miller's idea involves the use of diesel oil to keep a water hole open in the ice of a lake or stream. A 55-gallon oil drum, with both ends removed and supported by timbers, is inserted into a water hole (fig. 1). The drum is braced so that approximately 12 inches remains above the surface of the ice. Miller calculated that 30 gallons of diesel oil in the drum would be necessary to extend the oil level through 18 inches of ice to the water level.

After two successful tests of the device at Lake Hood, Anchorage Civil Defense officials reported these details of the project, together with their recommendations:

1. In areas faced with excessive icing, ice-hydrant oil containers should consist of two 55-gallon drums welded together for a total length of 72 inches. Any sturdily constructed steel or iron cylinder, such as 24-inch culvert pipe, will serve as well as 55-gallon drums.

2. By increasing the height of the oil column in the cylinder to 24 or 30 inches above the upper ice surface, sufficient oil pressure would be developed to reduce the degree of freezing below the oil level.

3. Twenty-foot lengths of 4½-inch hard suction hose are more adaptable for use in an ice hydrant than 10-foot sections of 4-inch hose. In pumping through an ice hydrant, the suction hose should be connected to the pump before passage through the oil cylinder into the water, in order to cut down or eliminate the intake of oil.

4. The degree of bend required to extend hard suction hose from a pumper through the ice hydrant indicates that an oil cylinder with a diameter of less than 24 inches would be impractical if not unworkable.

5. Hard suction hose to be inserted in the ice hydrant should be wrapped with masking tape as protection against oil damage. In the brief test, however, 6 feet of the exterior of the hose was covered with diesel oil, with no evidence of damage. Methyl alcohol was used to remove all trace of the oil after the test.

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[1]This slightly shortened article appeared originally in March 1956 as Fed. Civ. Defense Tech. Serv. (Fire Off.) Leaf. 289.

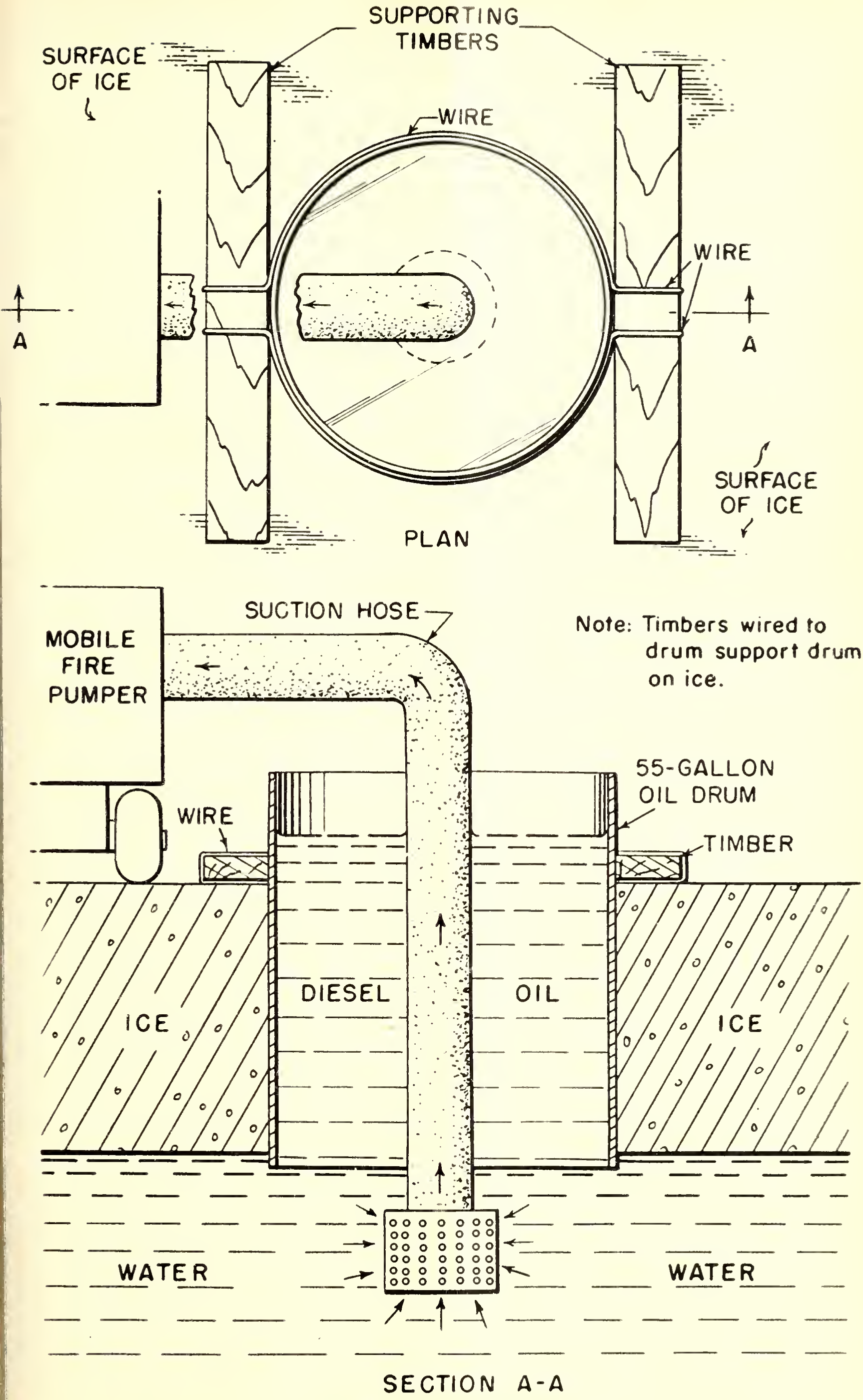

FIGURE 1.—Ice hydrant.

6. A tight-fitting, well-insulated cover for the ice hydrant will cut down the formation of ice and prevent humans and animals from falling into the oil-filled hole.

7. A 6-foot long ice chisel or bar and an 8- to 12-inch mesh strainer should be stationed near each hydrant for clearing and removing ice from the cylinder.

8. Until an oil-tight cover is developed for attachment to the intake end of the hard suction hose, the initial discharge of water should not be played on a fire. Such oil as enters the hose is cleared in a matter of seconds after pumping has started.

9. Before a thaw, the oil in the ice hydrant should be removed or burned to avoid water contamination or harm to fish or wildlife.

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The IBM and Forest-Fire-Report Computation

The State of Louisiana has 7,000 to 10,000 wildfires each year, most of which occur during a 6-month period. Until recently, the computation and recording of statistics from these fires required the services of a full-time clerical helper. During the height of the fire season the reports were so abundant that statistics could not be kept current; and during the green season there was time to spare.

The clerical position was not particularly interesting because of its routine nature, and this fact created a personnel turnover; with each turnover the system bogged down. The major weakness in our system, however, was borne out vividly after the 1952 emergency fire season. On top of the Gargantuan job of compiling the fire statistics came requests for detailed comparisons of fire records. It was next to impossible to meet this request.

The problem seemed to have no solution—i.e., until we decided to explore the International Business Machines System. Under this system the greater part of the information recorded on each fire report is punched into a card: Description of acreage burn (natural forest acres, planted or open); date of fire; district, parish or county; cause; time factors; equipment; man-hours; forest types and fire intensity (Class Fire Day); burning and build-up index; and damage.

The greatest single time and cost factor in this system involves punching the information into the cards. After that, summaries are mechanical. The cost per individual fire report is 18 cents as opposed to about 28 cents when computed by clerical help. In addition to this advantage, greater accuracy results, current information is available, and less storage space is required. Very soon we shall be in a position to furnish statistical comparisons in 2 days' time—a feat that used to take months or was impossible.—LAMBERT H. ROMERO, *Staff Forester, Louisiana Forestry Commission.*

EFFECT OF FIRELINE MECHANIZATION ON AREA OF BURNS

DIVISION OF FIRE CONTROL
Region 8, U. S. Forest Service

A question frequently arises as to how great a reduction in ire losses can be expected from the use of powered fireline-uilding equipment in the place of handtools. Past studies have ndicated that the reward of mechanization is a reduction in uppression costs and in size of burns and resultant damage. Iowever, findings from those studies were subject to qualifica-ions imposed by the limited number of years of mechanization nd extent of areas available for comparative study. Region 8 as now completed 10 years during which a significant number f ranger districts were sufficiently supplied with mechanized reline units to yield sound conclusions.

An analysis has been made of the records of 22 Coastal 'lain and 8 upland mechanized ranger districts to determine he number of fires and national-forest acres burned during the ast 15 years. The data were assembled by 5-year-period totals, vith the fast-fire-spread Coastal Plain areas separate from the pland districts. Although ranger districts were divided and ames and boundaries changed during the analysis period, each -year statistical period still covers the same protection areas.

The period 1941-45 reflects results of handtool fire fighting: ½ years of Civilian Conservation Corps labor and 3½ years of ired crews. However, there were some tractor-plow units at vork throughout that period, with increased number in 1945, vhich no doubt reduced the amount of timber that otherwise vould have burned.

During 1946-50 the design and quality of mechanized units vere improved and new units were acquired and assigned in umbers that gave the ranger districts an attack strength more early equal to their suppression problems. However. some of f the fires during peak loads still had to be fought by hand.

In the period 1951-55 only a few additional mechanical units vere acquired. Suppression action and results, however, were etter because of past experiences that developed clearer tactical oncepts of mechanized attack and increased the skill of the perators and supporting crews.

The base data employed in this analysis is massive, involving total of 24,344 Coastal Plain and upland fires on 5,383,138 cres, and covering the variety of forest conditions and fire roblems found in the approximately 1,000 miles from South Carolina to Texas. Because of the number of fires analyzed and heir geographic distribution, and the spread of time involved, uch effects as human error or seasonal variations are blended. The resultant figures also absorb the effects of the steady increase

in burning intensity and resistance to control occasioned b buildups in ground fuels and timber-stand densities that develope along with reductions in burned area.

The most significant revelation in table 1 is found in th end-result figures that show a saving of two-thirds of the aver age acreage lost per fire when mechanized suppression method are used. On the basis of present-day fire occurrence and wit continuation of handtool methods on these districts, assumin no increase in suppression difficulties, 44,000 acres would bur annually rather than 14,000 acres. The calculation of averag fire damage shows an annual saving in excess of $500,000. Thi indicated annual saving in damage alone is greater than th total investment in fireline equipment for the ranger district involved. They now have 91 tractor-plow units, a concentratio of 1 unit to 59,000 protected acres, with an average annua occurrence of 25.2 fires per 100,000 acres.

TABLE 1.—*Effects of fireline mechanization on average loss pe fire on 22 Coastal Plain*[1] *and 8 upland*[2] *national-forest ranger districts, 1941-55*

Suppression method	Coastal Plain			Upland		
	Fires	Total burn	Average loss per fire	Fires	Total burn	Average loss per fire
	Number	*Acres*	*Acres*	*Number*	*Acres*	*Acres*
Handtool:						
1941-45	7,183	279,775	38.95	2,078	21,100	10.15
Mechanized:						
1946-50	6,573	96,925	14.74	1,714	8,914	5.2
1951-55	5,132	63,050	12.28	1,664	7,817	4.7

[1]Alabama, Florida, Louisiana, South Carolina, Mississippi, Texas.
[2]Mississippi, Alabama, Georgia, South Carolina.

SODIUM CALCIUM BORATE AS A FIRE RETARDANT:

A Progress Report

HARRY R. MILLER

Forester, California Forest and Range Experiment Station[1]

[Because of its high abrasive and soil-sterilant qualities, the use of sodium calcium borate is limited to the California experiment until further experience is obtained and fire apparatus specifically designed to handle the mixture is made available. By agreement with the manufacturer, sodium calcium borate is supplied only through the California Forest and Range Experiment Station until the experiments have been completed.—Ed.]

Tests conducted in 1955 suggest that chemical fire retardants can open up a new era in forest fire control. Retardants were successfully used to hold the flanks and rear and cooler parts of the head of wildfires in brush and grass and for rapid construction of backfire lines. Aerial delivery of retardants was shown to be feasible.[2]

Several chemicals had shown promise for wild land fire control during Operation Firestop in 1954. Since only plot tests were used in Firestop, however, the practicability of using chemical retardants on going wildfires needed testing before research to develop the most effective methods and formulations was undertaken. Consequently, a cooperative research study was established to meet the following objectives:

1. To test the feasibility of using chemicals in wild land fire control under full-scale field conditions.
2. To gain information on the problems involved in the use of chemicals on fires.

Cooperators with the California Forest and Range Experiment Station in the field program were the California Division of Forestry, Los Angeles County Fire Department, and the Pacific Coast Borax Company.

TEST PROCEDURE

Sodium calcium borate was the retardant selected for use in this study. This substance is representative of the group of chemicals which retard firespread by their insulating qualities as well as chemical action. Sodium calcium borate is an ore mined and processed on the West Coast. The chemical is nontoxic to human beings and livestock. It is slightly corrosive to zinc and brass but is not corrosive to iron. Such borate compounds may be used as soil sterilants and herbicides when applied at the rate of 10 to 15 pounds per 100 square feet of surface area (fig. 1). Less

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[1]Maintained at Berkeley, Calif., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California.

This article first appeared in a slightly different form as U. S. Forest Serv. Calif. Forest and Range Expt. Sta. Forest Res. Note 105, CHEMICAL and Range Expt. Sta. Forest Res. Note 99, 12 pp., illus. 1955. [Processed.]

[2]ELY, JOSEPH B., AND JENSEN, ARTHUR W. AIR DELIVERY OF WATER HELPS CONTROL BRUSH AND GRASS FIRES. U. S. Forest Serv. Calif. Forest and Range Expt. Sta. Forest Res. Note 99, 12 pp., illus. 1955. [Processed.]

FIGURE 1.—An area in Amador County, Calif., 10 months after borate had been applied on a test fire at about 15 pounds per 100 square feet. Application inhibited the germination and growth of all annual grasses in the area treated.

than 2 percent of the material is soluble in water; but when finely ground, it can easily be put into a stable suspension at concentrations up to 8 pounds per gallon of water. Besides a high melting point (1,000° C.), the chemical has other properties particularly desirable in a fire retardant to be applied in spray form. It covers well and adheres well to vegetation.

Standard pumper tankers equipped with centrifugal pumps[3] were modified slightly for these field tests. Openings were made in the top plate of the tank so that dry chemical could be poured easily into the water. Agitation for mixing was obtained by leading a bypass pipe from the pump back to the bottom of the tank.

Before each unit was put into operation, its crew was oriented by personnel from the Pacific Coast Borax Company and the experiment station. Proper mixing and possible methods of application were demonstrated. One member of each tank-truck crew was trained to observe the effect of the chemical on fire and to record the information necessary for evaluating results. Crew foremen designated the method of application on each fire. In order to encourage exploration of different uses and techniques, precise procedures or limitations were not established.

[3]A small, positive displacement pump under test at the Arcadia Equipment Development Center was seriously damaged by the chemical within 10 minutes.

USE AND RESULTS

In spite of the severe 1955 fire season in California, the test units had only a few opportunities to use chemicals. Nevertheless, results were encouraging.

Wild land fires.—Approximately 5,800 feet of firelines, 4 to 6 feet wide, were pretreated (sprayed in advance of the fire) through grass and light to medium-heavy brush to hold the flanks, rear, and head of fires. The fuel was coated with retardant applied as a fine spray at about 3 gallons per 100 square feet, 5 to 30 minutes before it was reached by fire. This chemical line held except for one small section in grass which burned through at the head of a fire.

According to the associate State ranger in charge, the sodium calcium borate assured control of one flank of the 700-acre Camanche Fire that occurred in Calaveras County in September 1955. The fire boss reported that attempts to backfire from a plain waterline were ineffective, and the tanker crew was forced to abandon the attack. About 2,000 feet of chemical line was then prepared along the east side of the fire and fired from successfully.

Controlled burning.—On a moderate slope, 1,600 feet of line 6 to 8 feet wide was treated through grass and light to medium-heavy brush across the head and on the flanks of the fire. The retardant was applied to the fuel as a fine spray at 3.5 gallons per 100 square feet and allowed to dry 3 to 4 hours before the area was fired. The flanks and cooler parts of the fire head were contained by the chemical line. Hot parts of the fire head burned through the line. Experienced observers reported that these same fire heads probably would have swept across cleared firebreaks of the same width.

Spot fires.—A serious source of spot fires in the oak-woodland type was reduced by pretreating scrub oaks inside the fireline. Surface fuels at the base of trees and about 4 feet of the lower part of each crown were sprayed with retardant. The chemically pretreated scrub oak did not ignite and "crown-out," whereas untreated trees burned readily.

Backfiring lines.—The use of a chemical retardant for rapid construction of backfiring lines showed excellent possibilities as a fire tool. Crews moved through light brush and grass at a fast walk, applying retardant on 2- to 4-foot strips. Backfiring was successfully done from these lines 0 to 20 minutes later.

Direct attack.—The chemical was applied as a spray directly on burning light brush and grass fuels along 1,500 feet of fire edge. It appeared to be as effective as water in cooling down and extinguishing the fire. Fewer reignitions were observed than would normally occur when water was used under the same conditions.

Equipment.—A Bean type spray gun proved most suitable for applying the chemical directly to burning fuels. An overshot or basement applicator (in common use by city fire departments) equipped with a shutoff valve and a spray tip was used for pre-

treatment of fuels. This applicator, 5 feet long with a 30 degree bend about 10 inches from the tip, was excellent for spraying tall or dense brush.

Measurements on a Berkeley 4-stage centrifugal pump used in Amador County showed wear of .015 to .022 inch between the suction eye and wear ring of each stage, and .028 inch in the tail shaft bearing at the discharge end of the pump. Although this amount of abrasion is large compared to that experienced with clear water, it is about the same as normally occurs with dirty irrigation water. Much of the wear probably resulted from the mixing process, which required the chemical to pass through the pump several times.

Penetration and coverage of fuels were best when the sodium calcium borate was applied at a concentration of 5 pounds per gallon of water, through a spray nozzle of 4.5 to 7.0 gallons per minute capacity, and at a pressure of about 150 pounds per square inch.

Conclusions and Recommendations

1. Chemical fire retardants have a significant advantage over water for control of brush and grass fires. Chemicals can be used effectively to stop fires or materially reduce spread whenever heat output is not too great. This means that chemicals can be used to control small spot fires and the flanks, rear, and weak heads of large fires. The chief superiority of chemical attack over water lies in the long time that chemicals remain effective. This lasting quality of retardants permits treating fuel well in advance of the fire. For example, the chemical can be sprayed in a straight line ahead of a rough irregular fire edge, whereas water has to be applied directly to the fire edge.

2. Chemical retardants appear to have much broader uses in forest fire control than could be tested in 1955. Among potential uses which may be of major importance are aid in slash-fire control, widening existing firebreaks, and building fireline in rocky soil where bulldozers cannot be used. More intensive field testing under a wider variety of fuel and burning conditions is needed to establish the limits of potential chemical use.

3. Preliminary indications are that aerial application of fire retardants is feasible. Further development of techniques and equipment is needed to utilize the full potential of chemicals in this method of fire attack.

4. Equipment and methods to simplify and speed the mixing of chemicals with water are needed. If mixing could be done at the pump, then chemicals could be carried dry in hoppers and either water or chemical attack could be selected at will. Mixing at this point should also eliminate most abrasion in the pump.

5. In conjunction with field tests, laboratory studies are needed to determine the best formulations, concentrations, and application rates for various fire situations.

PREVENTIVE MAINTENANCE PAYS OFF

ROBERT F. WELLS
Missouri Conservation Commission

Preventive maintenance of vehicles and heavy equipment has paid dividends for the State of Missouri. Before our maintenance program was organized, we were troubled with constant breakdowns of equipment during critical periods, and also by costly repair bills. As the number of vehicles in operation by the department increased, the problem became acute.

Our program is organized with a Central Repair Shop to supervise the maintenance and repair of all the equipment. All new vehicles are received there, furnished with special equipment and sent on to the field. Major overhauls are also handled there. In addition, each Fire Protection District is equipped with a small shop where repairs and maintenance designated for the district level are undertaken. The work done at the district level largely accounts for the fine care our vehicles now receive.

Our entire program is geared in the operator's direction. Once each month an inspection is made at the district level to check the condition of each piece of equipment and determine what repairs are required. Constant pressure is exerted on the operators to see that they keep their equipment in the very best of condition. These inspections also serve as the means of keeping the operators informed on their progress. In addition, men from the Central Repair Shop visit the districts once a year and inspect all equipment. This inspection permits us to evaluate the effectiveness of the work of the district equipment men and the operators. It also furnishes information to be used in planning for the replacement of various units.

In order to compare the care given the equipment by the various districts, and as a means of judging the work, a system of numerical grading is used by men from the Central shop on their annual inspection. The maximum attainable grade is 100, and 75 is the lowest acceptable minimum. Grading takes into account the normal wear and tear on equipment and places emphasis on items that should be handled by the operator or district men. Districts are advised of the results of the inspection, and the relative standing of the various districts is given. The grade assigned to each piece of equipment is also available if desired.

The first year that numerical values were used, we had an average annual rating of 76 on a total of 110 units. Four years later we had an average rating of 93 on a total of 170 units. This upswing in average rating is a good indication of the effectiveness of our program of preventive maintenance. We have long since eliminated the problem of breakdowns during critical periods and the costly repairs that plagued us. Also, our operators have a pride in the appearance and condition of their vehicles that was not evident before the program was put into effect.

A secondary and perhaps more important result of the program has been the competitive effort between districts. District foresters and district-level maintenance men have striven to bring their districts's average rating up to or above that of other districts. Since one or two low ratings on a district lowers its average, more emphasis is placed on proper use of equipment to prevent unnecessary damage. The poor driver or one who fails to properly maintain his vehicle is considered an administrative problem and steps are taken to remedy the situation.

Another important result of the preventive maintenance program is that our trade-in vehicles require much less repair prior to resale than most trade-ins; dealers have therefore increased their allowances for our old vehicles. In many cases dealers do not even look at the units we trade in. The average trade-in allowance has increased about $100 since our preventive-maintenance program was initiated.

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Effect of Slash Burning on Some Physical Soil Properties, by R. F. Tarrant. Forest Science 2: 18-22. 1956.

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OL. 18 JANUARY 1957 No. 1

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 18 Number 1

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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Forest Service, Washington, D. C.

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CONTENTS

FIRE CONTROL PLANNING[1]

A. E. SPAULDING

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Although forestry in the United States received attention as early as 1876, it was not until the present Forest Service came into being that a rounded national policy for forestry was developed. Work then began to go forward with long-range objectives to maintain and increase the productivity of forest lands everywhere in the States. Working together, private and public agencies have made good progress in forestry during the last half century. We have effectively demonstrated the values of organized protection against fire, insects, and disease, and of good management and wise use of the Nation's forest resources.

Most of my forestry experience has been in the Northern Region of the U. S. Forest Service. In discussing fire control planning with you, my remarks will be directed at problems we have encountered in providing fire protection to some 33 million acres in Montana, northern Idaho, and northeastern Washington.

To illustrate our progress in fire control, I will divide the last half century into three periods that denote major milestones in fire control planning.

1. During the 1905-30 period our annual average burned area was 252,000 acres. Thus for the first quarter century, forest fires greatly damaged more than 6 million acres. During this devastation the forest was inaccessible and travel was by foot or horse. Fire control planners had long recognized the critical need to speed up attack on fires.

2. During the 1931-40 period, roads into many areas speeded up travel time to 15 miles per hour and the average annual burned area was reduced to 62,500 acres. This was double the destruction that we could afford if we were to meet our objective of managing the area for sustained crops. During this period, analyses proved that much of the excessive burned area was occurring in the remaining roadless areas. Some of these were dedicated to remain roadless and others were not developed due to lack of funds or high cost of road construction. Increased use of airplanes to speed up delivery of supplies during this period logically led to the delivery of fire fighters by parachute.

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[1]Paper presented at the 1955 Annual Meeting of Canadian Institute of Forestry at Saskatoon, Sask. Reprinted, by permission, from *Forestry Chronicle*, June 1956.

3. During the 1941-55 period, the growth of aerial fire control along with the use of smokejumpers speeded travel time to fires in remote areas and assisted in reducing the average annual burn to 8,000 acres.

With only these facts available, we might conclude that for this area the fire control manager has successfully met or bettered his objective and that no additional fire control planning is necessary. Such an assumption would be far from the truth if all the facts are known. A lot of good planning and a lot of good work contributed to the reduction in burned area. During the last 15 years, weather has also been more favorable than during the late 1920's and early 1930's. Smokejumpers in combination with the ground forces and other improved methods have in recent years kept fire losses and damages at a lower level. During the more severe fire years, available facilities are insufficient to man all fires soon enough and during such periods damaging and costly fires can still occur. This is a challenge to fire control planners.

Developments such as the helicopter, as it is improved and becomes available with larger capacity and operational ability at higher elevations; research findings in fire-danger measurements, knowledge and control of weather factors; technological developments such as radar for detection; and improved fireline-building machines and other projects will all receive consideration by the fire control planner to assist in solving this problem.

In the Northern Region of the Forest Service we are using the old methods as well as the new. Men still have to walk across country with packs on their backs; mules carry supplies and equipment over the trail system; travel and hauling by vehicles on roads is an essential part of fire control; pumps, tankers, and available fire-trench-building machines are used; smokejumping has become routine on wilderness-area fires; small helicopters are regularly used—in short, a combination of the old and newer methods of fire fighting is used that best meets the conditions at hand.

During the last half century, we have planned and replanned for adequate fire control. A fire plan must be a *living thing* subject to change, and I expect that we will go right on revising our plans as we strive to do a more efficient job.

DEFINITION OF FIRE CONTROL PLANNING

Planning for fire control on wild lands presents a different picture to different men. To me it is the determination of an acceptable objective along with the determination of all the measures needed to meet that objective. This is a broad concept of the subject. I believe we must so treat it to prevent an analysis and plan for only one or several of the many facets of fire control from being called a complete fire plan.

In the design of fire plans we usually attempt to provide for average worst conditions, recognizing that a normal plan will not cover the worst fire periods. This is similar to the principles an

engineer follows in designing a bridge that will meet needs with a reasonable margin but may not handle the worst flood or greatest possible overload. The plan should, however, go as far as possible in meeting the worst conditions on an emergency basis.

OBJECTIVE

The overall objective of the U. S. Forest Service in the fire protection of national forests is to hold fire damage below the level at which it would seriously interfere with the desired yield of products and services from forest land, and to prevent other serious adverse effects of forest fires, among which are such effects as those of public health, safety, or convenience—and to do the job at least cost. This is a broad objective and not sufficiently tangible to provide a foundation for plans of action.

Objectives for fire control are and have been a controversial topic. The theory of least cost plus damage has many supporters. An objective expressed in allowable annual burn has long been used for forest types, such as 2/10ths of 1 percent, or 1/10th of 1 percent. This objective, when applied to a large area, could mean the total allowable damage for any one year might occur in one local unit, causing untold damage and suffering to a dependent community. We are now making progress in setting up allowable burned area by management units in accordance with values and fire potential involved. When this has been done, the fire control planner can proceed to make an action plan to meet this objective.

In some cases the owners of forest property may have a fixed sum they will spend on fire control. If this sum is insufficient for adequate fire protection and cannot be increased, the fire control planner's job is to provide the best possible protection within the prescribed limits. With a rapidly increasing population, forest resources are becoming more valuable and experience has proved that it is good business for owners to buy good fire protection. The fire planner has a responsibility to inform the owner of the amount of insurance he is carrying on his property.

Many foresters believe that determination of an acceptable objective is a function of the resource manager or owner and not the fire planner. I placed additional responsibility on the fire control planner in my definition to emphasize the need for an acceptable objective as a foundation for planning and that he will need to get concurrence on an objective to do his job properly.

Following a review of the fire history and potential of an area along with values involved and the determination of an acceptable objective, the fire control planner should sufficiently understand the economics of the situation and be in a position to establish some balance between the three major divisions of fire control, namely, prevention, presuppression, and suppression.

I shall discuss each of these major subjects separately.

FIRE PREVENTION PLANS

A fire prevention plan, if needed, should be based on the following minimum analysis:

a. Study of risks.

1. An analysis of man-caused fires by causes for previous 5 years to determine specific reasons why fires start and who starts them.
2. Location of man-caused fires by causes for same 5-year period.
3. Location of areas of special risks, i.e., railroads, sawmills, woods operations, power lines, construction crews, towns, etc.
4. Dates when man-caused fires start.

b. Study of areas of special hazards.

Location of areas of special hazards, such as slash areas, blow-downs, fire- and insect-killed timber, etc., and careful identification and survey of local hazards in special-risk areas.

c. Correlation of all hazard areas with the risk factors.

This is to provide a clear overall picture of the fire-starting and/or spreading potential, to identify the areas and periods of special fire liability, and to facilitate the setting up of priorities.

General Principles in Development of Action Plans

Fire prevention planning, which concerns itself with the problem of reducing total costs and damage, must recognize fire risks, forest fuels, and other fire hazards as critical factors in undertaking remedial action.

The time of day, year, place, and the number of fires that start, usually control the size of the fire organization that must be maintained, and are decisive, too, in the fire-fighting costs and damage that result.

Where these things depend on the exposure of critical fuels to human risks, attainment of the whole objective requires the kind of management that will remove or reduce the risk or the fuel hazard, or that will minimize the potentials of one or both.

Objective

The objective of fire prevention is to eliminate preventable fires. Final attainment of such an objective is necessarily limited by many factors, but levels of attainment far short of this goal are not regarded as acceptable unless the additional cost of improved performance will clearly exceed the benefits gained in reduced losses and suppression costs.

Action Plan

Following consideration of the above factors, an action plan will be developed for each unit. This action plan specifically sets forth *what* shall be done, *where* it shall be done, *when* it shall be done, and *who* shall do it, with provision for recording degree of accomplishment.

The action plan is an annual work plan and should be made each year as changes in responsibility assignments are usually made from year to year.

The analyses that precede the preparation of the action plan should be made once every 5 years, as a minimum, and oftener when material changes occur in the risks involved.

PRESUPPRESSION PLAN

The basic elements involved in presuppression planning are as follows:

a. Meteorological factors including wind, relative humidity, fuel moisture, precipitation, seasonal effects, etc.

b. Topographic factors relating to configuration of the country, such as ridges, slopes, streams, canyons, draws, etc., and the relative location of one to the other, elevation, steepness, soil conditions, barriers, etc.

c. Fuel factors including (1) types of fuels such as mature timber, second growth, slashings, brush, grass, forest litter, down logs, snags, etc., (2) continuity, density, and arrangement of fuels, (3) their resistance to line construction.

d. Occurrence dealing with incidence of fires as to points of origin, intensity of occurrence identified separately for lightning and each man-caused category, times of day and year fires may be expected to start and do damage.

e. Visibility as it applies to distance incipient small forest fires may be seen by detectors, normal daily or seasonal changes in visibility distance, etc.

f. Accessibility. Availability or nonavailability of roads, trails, ways, fire lanes, bridges, airstrips, lakes or rivers for airplane landings, helicopter landing spots, etc., and the travel time, by the most appropriate means, required to reach areas of fire occurrence.

g. Relative values (tangible plus intangible) at stake are one of the considerations in deciding the placement or intensity of the presuppression organization.

h. Rate of production of held line per unit of manpower or machines for different conditions, including delineation of areas where machinery is usable.

i. Water supply for suppression as related to portable pumper chances or tanker-filling facilities.

j. Equipment. Trucks and pickups, trailbuilders, tankers, aircraft, tools and related equipment for fireline work, and other facilitating gear.

k. Communication. Radio or telephone, or in combination, for presuppression and suppression.

While not strictly a basic element of planning, the need for providing plans for recruitment of suitable personnel to fill each planned fire position, including cooperators and their subsequent training to do the job efficiently and safely, must be recognized in order to carry out the master presuppression plan. Provision must be made also for recruitment and on-the-job training of able-bodied emergency fire forces.

Objective

Objective of the presuppression plan shall be to have available, when and where needed, an effective fire control organization, well trained, equipped, instructed and supervised, and capable of handling efficiently the fire suppression situations which sound planning determines to be necessary.

Master Presuppression Plan

In the development of a presuppression plan for each area, all of the basic elements mentioned above must be thoroughly considered as to their effect on that unit. The master presuppression plan is a term applied to a grouping of the following plans dealing with the detection and preparedness phases of the fire control job:

a. Detection

Detection involves consideration of visibility distance; zones of occurrence of fires as indicated by past history, and changes in risk areas due to changing use; maps showing extent of area seen from individual points; selection of points by process of statistical elimination; final map showing seen and unseen area from all selected points; establishment of dates of occupancy and provision for regulation of occupancy in accordance with measured fire danger; incorporation of aerial detection—either primary or secondary.

b. Initial Attack

Initial attack usually involves mapping of fuels to show combined effect of rates of spread and resistance to control; occurrence of fires by intensity zones; accessibility; initial-attack strength by zones required for varying degrees of fire danger;

location of crews to meet travel-time requirements; provision for varying strength of crews in accordance with measured fire danger, to meet initial-attack requirements for each zone; establishment of dates of employment, and recognition of the need for reinforcements.

In the Northern Region of the U. S. Forest Service, we have made major changes in our detection and initial-attack plans. During the early 1930's we intensively mapped fuel types, determined hour-control requirements, and ground detector needs. As a result we constructed approximately 800 lookout houses. Men hired for these stations had a dual capacity as lookout-firemen and other firemen were placed in valley bottoms when needed to complete the hour-control coverage. This system was successful as long as we could hire the number of men needed; men who were rugged woodsmen, capable of finding a fire and putting it out, and willing to live alone all season. Under our current economic conditions such men are not available in sufficient numbers at the salary we can pay and for only a seasonal job.

This placement of men did not provide for needed flexibility in moving men rapidly to another location where more than two or three men were needed for early attack on a difficult small fire. We also found that the comparatively few firemen stationed in the valley bottoms, particularly those on roads, became the initial-attack force on a majority of the fires.

The 800 lookout towers were constructed from untreated native woods obtained close to the site and after 20 years they all began to deteriorate rapidly and many became unsafe for use. In addition we gradually became financially unable to maintain trails and telephone lines to all of these stations. As a result we gradually changed our plan by moving some of the lookout-firemen to double-up firemen positions in the valley bottoms.

In the early 1940's, many of these fireman positions in the roadless areas were abandoned and were replaced by a centralized smokejumper unit. Because of their flexibility, smokejumpers have replaced twice their number of firemen. Two or more smokejumpers can now get to a fire as quickly as one fireman did when we had many of the latter strategically placed in the roadless areas. Where we used to get one man to a fire within one hour, but to get 20 there might take 2 days, we can now put 20 smokejumpers on the fire within one hour when the situation warrants. This is where flexibility pays off. There are times when the number of smokejumpers is insufficient to meet the need. We then resort to use of helicopters as far as they are available and can be used, and then must rely on slow foot travel to meet the remainder of the need. I might well mention here that smokejumping has great public appeal and in our area receives 90 percent of the fire control publicity. Actually smokejumping takes care of less than 20 percent of our fires with the remainder being handled by older conventional methods.

Our detection system has also been overhauled in recent years. We now have a skeleton force of about 200 lookouts who are

primary detectors covering the high-risk areas. They are important in charting the course of lightning storms, precipitation, in making burning index measurements, and in serving as radio communication hubs. Planned aerial detection fills in most of the gaps left in the reduction from 800 to 200 fixed detectors. Flexibility gained here is also important as it costs little to leave the airplane on the landing strip when this additional detection is not needed. With fixed detectors only, we had little flexibility, as a station in a remote area could not be occupied only on the days needed and the man not to be paid on other days.

c. Equipment

1. *Small tools.* Determination of types and quantities of tools for each initial attack and cooperator station; also, determination of small-tool and equipment requirements for regional, forest, and district warehouses for followup forces.

2. *Transportation equipment.* Study of transportation needs of each initial-attack station, ranger's and supervisor's headquarters.

3. *Specialized equipment.* Determination of types, quantities and locations of tank trucks, prime movers, plow units, trail-builders, portable pumpers, aircraft, and other specialized equipment; involves the types and quantities of specialized equipment required for initial attack, forest and ranger stations, and regional or zone central caches.

d. Communication

Communication—radio and/or telephone. These include:

1. *Detection.* Plan providing communication outlets for detectors—must provide immediate channels for detectors to report fires to dispatching base.

2. *Initial attack.* Provision must be made for immediate communication between dispatching base and initial-attack crews whether cooperators or employed by Forest Service.

3. *Dispatching base.* Must provide immediate communication outlets from dispatching base to all detectors, initial-attack crews, followup forces such as work crews and cooperators, and to forest and ranger headquarters.

4. *Suppression.* A plan must be made which will provide communication both from the fireline to the camp or to other sections of the fire, and from the camp to the dispatching base; numbers and types of radio, emergency phones, or other communication facilities required for these purposes must be determined. Communication between initial-attack crews when away from their stations and the dispatching base must likewise be provided whenever possible and made a part of this plan.

e. Cooperators

Determination of the extent to which cooperators may be incorporated into the presuppression phases of fire control. In many cases cooperators may be used in the initial-attack field, releasing funds for other areas where cooperators are not available.

f. Training

A training plan must be prepared, listing the minimum training needs of each presuppression position—lookouts, suppression crew foremen, crew members, tank-truck operators, patrolmen, packers, tractor operators, fire control assistants, and others who may be assigned full time or temporarily to fire control work of any kind. Provision should be made to maintain a current record of progress in training each individual. This plan should require an annual analysis of each incumbent's experience and training prior to entry on duty, to determine what he or she needs to learn to qualify for the position and to handle effectively and safely the assigned tasks.

g. Dispatching

Annually, a dispatching plan, sometimes termed "emergency fire plan," should be prepared, providing information on the location, strength, and provisions for contacting and mobilizing the following, with the purpose of providing adequate forces to meet the Service suppression policy:

1. All initial-attack stations—Forest Service or cooperator.
2. All Forest Service work crews.
3. All private work crews, i.e., logging, mill workers, railroad, power companies, orchard workers, etc.
4. Initial-attack forces of cooperating protection agencies.
5. Followup forces or facilities of cooperating protection agencies.
6. Forces of adjacent national forests.
7. Pickup fire fighters.
8. Overhead, segregated as to skills from which fire overhead teams may be selected, or from which assignments to individual fire suppression jobs may be made.
9. Cooks, packers, power-saw operators, trailbuilder operators, and others having specialized skills.
10. Tools and equipment, including transportation equipment, trailbuilders, tank trucks, etc.
11. Food, mess equipment, first aid, and other supplies and materials.
12. Communication equipment, including emergency wire, field telephones and radios.
13. Special detectors.

Also the dispatching plan should include ways and means and authority for varying the disposition or strength of the presuppression force in accordance with measured fire danger.

h. Housing

Because of its importance, a housing plan should be incorporated in the master presuppression plan which should indicate the housing facilities required to effectuate the plan and the housing facilities available. Changing patterns of use or fuel conditions should be given full recognition and weight in deciding whether to provide portable, semiportable, or permanent housing facilities, in order to permit ready shifting of forces to meet changed conditions.

i. Recruitment

A recruitment plan must be prepared and revised annually to provide the best possible (1) presuppression force, (2) force for use in fire emergencies.

j. Transportation

Plan usually outlines diagrammatically on map or maps the location and standards of all roads, trails, bridges, airstrips, and helicopter landing spots needed to meet the elapsed-time standards for the area; primary consideration is to provide accessibility for initial-attack and followup forces.

FIRE SUPPRESSION PLANS

Fire suppression plans separate and apart from the presuppression plan are not normally made by us in advance of the actual fire. Most material that would logically belong in a fire suppression plan has already been included above under the heading of presuppression plans. However, we do have a number of situations where an especially high fire hazard may require the making of a special fire-fighting plan in advance of fire occurrence. Such a plan is helpful to the fire boss once the fire escapes control of the first-burning-period attack force. They cannot always be followed but the detailed map of fuels, topography, cover type, roads, water chances, etc., provide an excellent basis for revising the plan to meet conditions immediately at hand.

Policy

Our policy is to require fast, energetic, and thorough suppression of all fires. When first-attack forces fail to attain this, the policy then calls for prompt calculating of the problems of the existing situation and probabilities of spread; and organizing and activating adequate strength to control every such fire within the first work period. Failing in this effort, the attack each succeeding day will be planned and executed with the aim of obtaining control before 10 o'clock of the next morning.

Calculation of Probabilities

Probably a better term for calculation of probabilities is an *estimate of the job we must do to control the fire.* Controlling a fire can be compared to building a road or a bridge. The fire boss needs a plan based on the job he will have to do. This includes evaluation and correlation of the factors affecting fire behavior, knowledge of the probable perimeter of the fire at successive time intervals and the expected number of units of held line per unit of manpower or applicable machine unit or both, to determine the organization—including overhead, manpower, and equipment—he will need. The fire suppression plan of action is then prepared day-by-day to meet actual conditions and revised at shorter intervals when the situation warrants.

Actuarial Planning

Some authorities on fire control planning do not agree with the subject divisions used above in this presentation. Ralph Hand, who recently retired after 15 years in the fire planning job in Missoula, divided the subject into prevention, detection, and suppression. I believe that this has merit and should be considered when preparing for a job in fire control planning. Ralph Hand also developed a system based on actuarial principles for suppression planning that is interesting and highly successful. Briefly, this system provided a series of actuarial tables based on an analysis of 20 fire seasons and 27,000 fires. Each fire was refought on the basis of present-day conditions of transportation, fuels, and methods. In these tables we had the facts that would give us answers to almost any specific question in the field of fire control planning. They were particularly valuable in—

1. Determination of basic needs, such as manpower, machines, and equipment.
2. Determination of facilitating needs such as transportation, communication, supervision, and training.
3. Preparing the action plan.
4. Providing the facts to indicate the amount or level of fire insurance that was being carried on a forest property.

This subject of fire planning by actuarial principles to explain fully would take an entire day; however, I would like to recommend that these principles be investigated before replanning is started where fire records are available for the area for the preceding decade or a longer period.

SUMMARY

To finish this paper and open the discussion period, I would like to state that this is far from a complete coverage of the subject. I have borrowed much of my text from our National Forest Manual and make no claim for originality. In closing, I'd like to again emphasize that a fire plan must be a living thing, frequently modernized, to be most useful.

CARRYING CASE FOR PORTABLE FIRE EXTINGUISHER

Andrew R. Fink
Draftsman, Division of Fire Control, Region 1, U. S. Forest Service

A canvas carrying case for fire extinguishers (fig. 1) has been developed in Region 1 for use by operators of power saws, duffel carriers, scooters, trail graders, and other gasoline-powered equipment. The U. S. Forest Service and most State and private protective districts in western regions require these operators to keep in their immediate possession a serviceable fire extinguisher with contents of not less than 8-ounce capacity by weight.

It is recommended that each man doing mechanized trail maintenance work have immediate access to a fire extinguisher.

Some of the advantages of this canvas carrying case are as follows:

1. By having it fastened to the man instead of the machine, "You wear it." If the case is worn, it is readily accessible at all times while the wearer moves about from one machine to another. It does not interfere when working or sitting. It is put on in the morning and removed only after the day's work or when the job is finished.

Figure 1.—Fire extinguisher case in place on belt. A sharp pull on tab will release extinguisher for emergency use.

2. Container is safe from brush and accidental misplacement.

3. "Break cord" is broken only when extinguisher is inspected or used. The method of fastening the cover was selected to ensure fast emergency use.

4. The lace-type break cord holds the package tight and smooth and the carrying case will cover extinguishers of various kinds and shapes.

The canvas case is of simple design. The cost of complete unit (materials and labor) is estimated to be about 80 cents. Substitutions in materials may be made without affecting the use. Several pressurized and "beer can" types of extinguishers with contents of approximately 12 ounces will fit in the case.

Drawings and specifications may be obtained by writing to the Regional Forester, U. S. Forest Service, Federal Building, Missoula, Mont.

PRESENTING FOREST FIRE FUNDAMENTALS

NEIL LEMAY
Chief Forest Ranger, Wisconsin Conservation Department

Young America has returned to the classroom with the advent of the fall season. The schools are charged with a great responsibility once again. In the presentation of the courses employed in the formal education of each student, instruction in conservation of the natural resources of the community, the State, and the Nation is of extreme importance to the student and to all of us. What he or she learns in school on this highly important subject will have an individual and cumulative effect not only on the person and his or her associations in future years but on the destinies of many people.

Those of us in fire control have been vested with a great responsibility. To protect and preserve the natural riches of the country, as well as the man-made and operated developments, we have the job of guarding against that foremost of destructive agents—wild, uncontrolled fire in the forest. To curb this menace we need the full, wholehearted cooperation of everyone, and our fire-prevention programs are highly diversified so that everyone will be reached.

For nearly 30 years, here in Wisconsin, we have been carrying on in the schools an educational program aimed at the forest fire menace. The high degree of success achieved in this venture shows in the strong support that Young America provides in the all-out effort directed toward prevention of forest fires. But the prevention job is not and probably never will be completed. We, therefore, must be prepared for fire control work.

As most of us know, fire control work is a highly technical endeavor. It embraces many fields; meteorology, communications, mechanical aptitude, engineering, personnel management, and public relations, to name a few. This can be confusing to the student even though it may seem simple to those of us who have spent most of our lives working at it. Because successful fire control work is based upon the knowledge of why a fire burns and what makes a fire spread through forest fuels, we start at the very beginning. We have found that a thorough understanding of the fundamentals of why a fire burns is essential not only to the forest ranger but also to the student in school. We have worked out a method of displaying this which we believe may be helpful to other fire control agencies. I am presenting this method of instruction in the fundamentals of forest fire occurrence for your information (figs. 1-6).

FIGURE 1.—Before a fire will start and burn, there must be thre elements present in the right combination. They are fuel, ai and heat. Fire cannot exist in the absence of any one of thes three elements. The basic principle of fire suppression is t remove one (or more) of these elements.

FIGURE 2.—When I close the "fuel" flap, the "fire" disappears. To demonstrate this, I separate the unburned fuel in the pan from the burning fuel. The fire goes out quickly. This is a common method of control employed to stop forest fires. In the forests we use fireline plows, bulldozers, and handtools to make the separation.

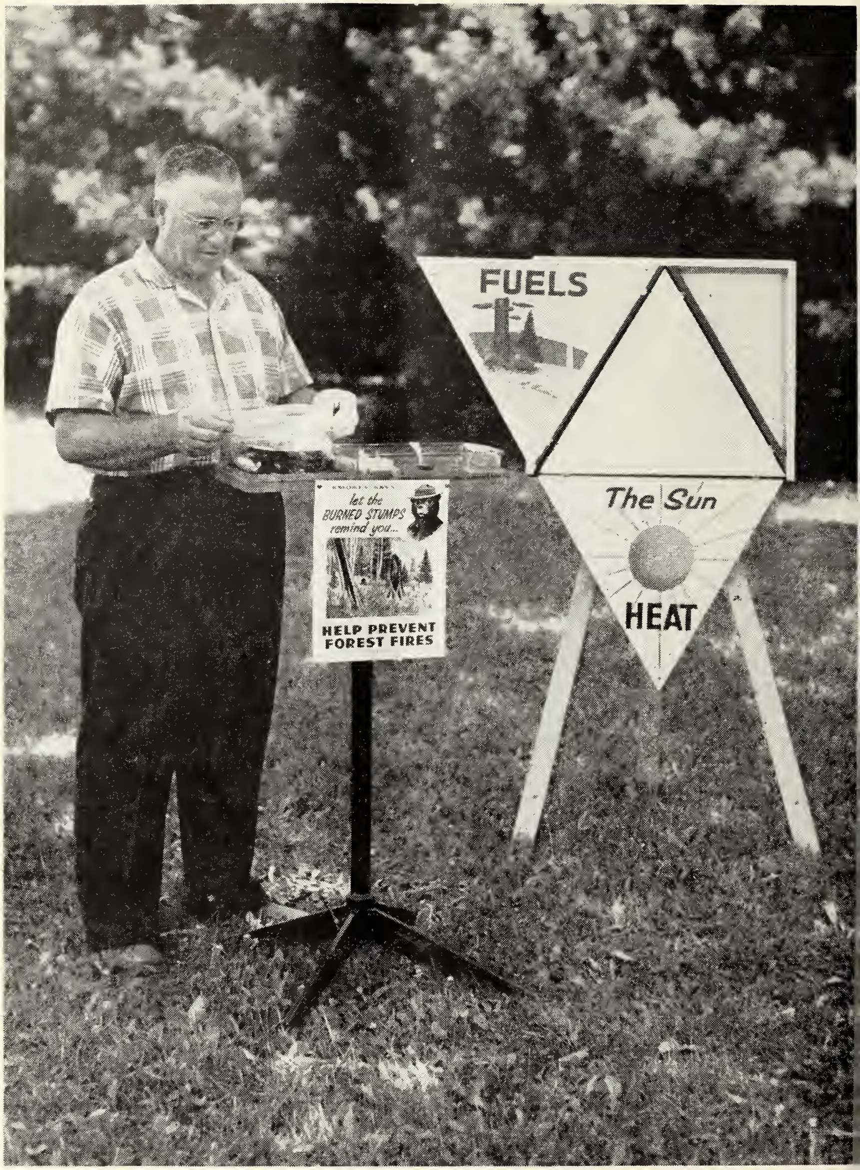

FIGURE 3.—In this scene, I have reopened the "fuel" flap but have closed the "air" flap. Again the "fire" disappears. To demonstrate this, I start a fire in the bowl and then place the cover on the bowl. The fire soon goes out because of lack of air. In forest fire control this method of suppression is used to extinguish burning embers by completely covering them with mineral soil to shut off the oxygen supply. It is used principally on small fires or on parts of a large fire.

FIGURE 4.—After reestablishing the original scene, I close the "heat" flap and the "fire" disappears again. To demonstrate this, a fire is started in the bowl. Water is sprayed on the flames, quickly extinguishing the fire. Water is widely used as a suppression agent by all fire control organizations. Pumps and tanks are mounted on trucks and tractors for use in all types of suppression work. Often independent water-pumping complements are used to extinguish fires.

FIGURE 5.—In forest fire prevention work these three basic fir occurrence elements also play an important part. We canno control the oxygen supply as "air" is everywhere. Fire protec tion agencies can control "fuel" deposits to a limited exten only although laws regulating the removal of slash resultin from timber-cutting operations, right-of-way cleanup alon roads and railroads, and special forest fire hazard reductio projects are helpful. Also, lightning is one source of "heat over which we have no control. Quick detection and suppres sion action is the only answer when this element is present i the right combination with the other two.

FIGURE 6.—We can do something about curbing the man-caused sources of "heat." It is in this connection that our fire prevention programs in the schools, civic clubs, sportsmen's groups, industry, local government, and with people, singly or collectively, will pay off. Past records indicate a need for a never-ending endeavor in this direction.

I hope that this teaching aid will be helpful to you. It has proved to be very useful here in Wisconsin. If you are interested, please feel free to write me for details relating to construction and operation.

FIRE WHIRLWIND FORMATION AS FAVORED BY TOPOGRAPHY AND UPPER WINDS

HOWARD E. GRAHAM

Fire-Weather Forecaster, U. S. Weather Bureau, Portland, Oregon

A fire started at a logging operation during the afternoon of October 1, 1952. Toward evening the size had slowly increased to 20 acres. About 9:30 p. m. the fire suddenly became a raging inferno as whirling winds formed within the fire and abruptly multiplied its speed to such strength that chunks of wood and bark up to 8 inches in diameter were thrown about like straws. Logger fire fighters fled for their lives. Within minutes the fire raced through unburned areas for half a mile, increasing to 240 acres. The whirling winds remained over the fire for about an hour, hurling burning embers for considerable distances and preventing the loggers from pressing their attack (table 1, whirlwind 4).

Fire whirlwind is a phenomenon that has been known to be associated with large fires (whirlwinds 1, 2, and 3) (*4*).[1] It has become more common in recent years in the Northwest as a result of the increase in number of necessary slash burning operations.

In another fire that occurred November 8, 1952, a Crown Zellerback fire patrolman was making a routine 8:30 a. m. visit to a nearly cold 2-acre slash fire on the west slope of the Washington Cascades near the Columbia Gorge. Although the lookout on a ridge a short distance eastward reported east winds from 50 to 60 miles per hour, these winds had not been hitting the fire area. Suddenly an intense whirlwind formed in adjacent green timber and passed over the dormant slash fire. The fire leaped to life with an eruption of sparks and flame and ran for over a mile finally joining a second fire (whirlwind 9).

Fire whirlwinds have received little attention from meteorologists, probably because such winds are usually observed only by foresters and fire fighters who are too busy fighting fires to make detailed weather observations. With greater attention being given to the study of blowup fires (whirlwinds 1 and 4), it is fitting that this particular type of violent fire behavior be explored from both the empirical and theoretical standpoints.

Winds are of great concern to fire fighters. Fire spread is a function of wind speed, although not a simple function. Local violent winds, frequently whirlwinds, have many times caused unusually rapid fire spread due both to direct fanning and to spotting. A typical fire whirlwind frequently has a central tube made visible by whirling smoke and debris. Extreme variations in height, diameter, and intensity are common. Witnesses have described fire whirlwind diameters from a few feet to several hundred feet and heights from a few feet to about 4,000 feet. Inten-

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[1]Italic numbers in parentheses refer to list of references p. 24.

TABLE 1.—Descriptive details for 28 fire whirlwinds in the Pacific Northwest

Whirlwind number	Day and hour, Pacific standard time	Whirls: Number	Whirls: Duration	Whirls: Diameter	Whirls: Height	Size of debris picked up	Wind-topography relation	Ridgetop wind: Direction	Ridgetop wind: Velocity
				Feet	*Feet*				*M. p. h.*
1	7/20/51 1600	1	2 hrs	1,200	2,500	logs, 30 in. by 30 ft.	lee slope	N	
2	8/23/51 1400	3	10 min.	200	1,000	large tree broken off	" "	N-NE	10-15
3	9/21/51 1300	1	1 hr.	200	4,000	logs, 15 in. by 15 ft.	" "	N-NE	
4	10/ 1/52 2140	(1)	several min. each for 1 hr.	50	200	6- to 8-in. chunks	" "	E	30
5	10/15/52 1500	(1)	each 30 sec.	40	150	3 by 4 by 16 in.	" "	NE	10
6	10/24/52 1030	(1)	each 30 sec.	40	300	log, 12 in. by 16 ft.	" "	E	10
7	10/25/52 1100	(1)	each 2 min.	20	150	bark, 2 by 4 by 12 in.	ridgetop	W	
8	11/ 4/52 1400	1	few min.	(2)	(2)	(2)	parallel to contours	SW	10
9	11/ 8/52 0830	1	(2)	(2)	(2)	small debris	lee slope	E	50-60
10	11/ 8/52 1500	1	1 hr.	5	100	small sticks	" "	E	10
11	9/ ?/53 1100	1	10 min.	50	100	small limbs and snapped tree top, 8- to 10-in. diameter	flat	calm	
12	9/16/53 1345	1	2 min.	75	125	bark and wood, 4-5 lbs.	lee slope	S-SW	4
13	9/21/53 1530	1	¾ hr.	25	100	6- to 8-in. diameter	" "	SW	15
14	9/29/53 1000	(1)	each 30-60 sec.	10	50	up to 8 sq. in.	windward	SW	10
15	9/29/53 1130	1	1½ hrs.	400	400	up to 3 by 3 in.	lee	W	2
16	10/ 3/53 1600	(1)	each 2 min. for 8 hrs.	10	30	up to 15 lbs.	windward ?	E	30
17	10/ 4/53 1150	(1)	3 min.	40	300	2 by 6 by 18 in. and a cedar post	lee slope	NE	5
18	10/ 6/53 1530	1	1½ hrs.	50	200	(2)	calm	calm	
19	10/ 6/53 1530	(1)	½ hr.	20	60	bark, 4 by 6 in.	lee slope	E	8
20	10/ 7/53 1500	(1)	each 30 sec.	30	100	1½ in. diameter	windward ?	SW	10
21	10/ 8/53 1600	(1)	each 4-20 sec. for 4 hrs.	10	200	under 1 lb.	windward	W	10
22	10/ 9/53 1640	1	8 min.	140	170	2 by 6 by 24 in. and larger	lee slope	NE	5
23	10/ 9/53 2000	(1)	1-2 min. each for 2 hrs.	75	100	1 by 2 by 3 in.	" "	SW	10-15
24	10/10/53 1730	5	1 hr.	50	125	large sparks	" "	W	5
25	10/13/53 1830	(1)	1 min. each	30	200	small twigs	" "	W	8
26	10/15/53 1500	(1)	each 1-2 min. for 1 hr.	50	150	branches and bark	" "	W	5
27	10/29/53 1830	1	10 min.	100	80	bark and limbs, 4 by 5 in.	" "	N	3
28	10/29/53 1500	(1)	each 10 sec. to 4 min. for 2 hrs.	30	60	large material including a 20-lb. piece of sheet metal	" "	W	5

[1]Several.
[2]Unknown.

sity varies from that of a dust devil to a whirlwind that pitches logs about and snaps off large trees (*3*). Velocities in the vortex are extremely high, and, as in other forms of whirlwinds, the greatest speed occurs near the center. A strong vertical current at the center is capable of raising burning debris to great heights.

FAVORABLE TOPOGRAPHIC FEATURES

The 28 fire whirlwinds that form the basis for this discussion were all observed in mountainous terrain. Their individual characteristics are indicated in table 1. Of the 28 whirlwinds, 20 occurred on lee slopes, 1 on a ridgetop, 1 under calm conditions, 2 with wind at right angles to the slope, and 4 on windward slopes. Of the several additional whirlwinds described to the author and not included in table 1, all occurred on lee slopes. From observations it would appear that the most violent whirlwinds occur on lee slopes.

The mechanical action of airflow over a mountain is a factor in fire whirlwind formation. Aerodynamic theory tells us that favorable conditions for the starting of a whirl occur where abrupt edges of mountainous terrain create shear in the air stream. As has been found true with dust devils, shearing motion is undoubtedly a major factor in whirl formation. Although mountainous terrain provides many topographic situations favorable to fire whirlwind occurrence, the fact that it is not an essential condition is indicated by several examples which occurred on flat land in Eastern United States (*2*).

METEOROLOGICAL ASPECTS

Dust devils are normal in flat areas when the wind speed is low and the lapse rate is steep, i.e., relatively rapid temperature decrease with height. Fire whirlwinds also appear to depend upon steep lapse rates in the layer near the ground. Roy R. Silen, Pacific Northwest Forest and Range Experiment Station forester, moved a fire whirlwind downhill by rolling debris against the fuel in the hot spot over which it had formed. As the hottest portion of the fire was carried down the slope, the fire whirlwind followed. Fire whirlwind occurrence seems to be directly related to the local thermal instability set up by the fire and not otherwise relieved.

The degree of upper air stability as indicated by the lapse rate between 850 and 500 millibars, i.e., pressure surfaces near 5,000 feet and 18,000 feet, at nearby weather stations has little or no effect on fire whirlwind occurrence. Data on the lapse rate at lower levels is unavailable. Obviously the lapse rate in the lower level over the fire is extremely unstable because of intense heating near the ground.

The distribution of upper air wind velocities also was checked from pilot balloon data at the nearest weather station. The results showed that 75 percent of the whirlwinds reviewed occurred with winds of less than 17 miles per hour below the 5,000-foot level.

This is to be expected since the majority of whirlwinds were on controlled burns. The remaining 25 percent showed rapid wind speed increase with height. The wind speed profiles are of variable shape and show no typical occurrence of the "jet point" discussed by Byram (*1*) with relation to blowup fires.

MOUNTAIN BARRIERS AND THEIR EFFECTS ON AIRFLOW

The upper end of a fire whirlwind when on a lee slope near a ridgetop seems to extend into a region of low pressure that occurs in the vicinity of a ridgetop whenever windflow is at right angles to the ridge. This follows the Bernoulli principle which states that changes in pressure are inversely proportional to changes in fluid velocity. Pilots are taught this principle as the explanation for altimeter errors experienced over mountains.

The theory of pressure reduction along a ridge oriented at right angles to the direction of airflow is well supported by evidence. According to a U. S. Weather Bureau study of strong winds over mountain barriers, the pressure reduction over a mountain crest was proportional to the square of the wind speed. Where the air was saturated, the pressure deficiency was nearly doubled. The greatest pressure deficiency occurred along a mountain barrier with a ridge profile corresponding to the upper surface of an airfoil where the maximum drop would be near the topmost part of the airfoil camber. Theoretically a topographic barrier should best approximate an airfoil when the lee slope is less than 33 percent and relatively smooth. This corresponds very closely to the upper limits of the change in direction of airflow over the upper surface of airfoils on slow speed airplanes.

CONCLUSION

Because of the direct relationship between fire whirlwind occurrence and combustion heat, the meteorologist can predict likely areas of occurrence only if he is familiar with both the attendant meteorological and topographic conditions and the occurrence of heavy fuel concentrations. The forester with intimate knowledge of areas under his management will usually be more able to predict combustion heat over a given area.

Fire whirlwinds seem to develop more readily on lee slopes close to ridgetops. It is suggested that this is favored by pressure deficiencies resulting from flow over an abruptly terminating airfoil. The wind velocity above the ridgetop thus becomes an important factor in determining the likelihood and magnitude of a whirlwind.

We may conclude that the most favorable condition for fire whirlwind occurrence is over a hot fire near the top of a steep lee slope with strong winds over the ridgetop. Fire whirlwinds are frequently characterized by destructive violence. Therefore, when any fire—large or small, quiet or running—is on a lee slope, the fire fighters should consider the danger of fire whirlwind formation.

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WESTERN OREGON FOREST LAND ZONED FOR CLOSING DOWN LOGGING DURING PERIODS OF HIGH FIRE DANGER

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The State Forester of Oregon is authorized by law to prohibit the use of fire in any form or the use of power-driven machinery on forest land west of the summit of the Cascade Mountains during periods of critical fire danger. These periods occur when there is a combination of critical fire weather and an excessive amount of forest fuels. The area includes about 10 million acres of forest land and is bounded on the north by the Columbia River, on the east by the summit of the Cascades, on the south by the California State line, and on the west by the Pacific Ocean.

Extremes in elevations, wind directions, temperatures, rainfall, and other factors naturally produce a wide range in climatic conditions. High fire danger may exist in a part of the area while in other sections the danger may be moderate or low.

Climatic and soil conditions in western Oregon result in the growth of heavy stands of timber and a luxuriant growth of underbrush and other vegetation. Logging operations on more than 400,000 acres each year leave an enormous amount of slash and debris on the ground. Unburned slash and areas in the process of being logged can become extreme fire hazards during the summer season.

Closing logging operations results in a tremendous economic loss to the State. Operation close-down orders can be justified only at such times and in such localities where critical fire danger makes the use of fire in any form or the use of power-driven machinery a potential cause of fire that could not be controlled. A careful study of conditions that influence the starting and spread of fire must be made before close-down orders are issued. Obviously the authority to close down all forest operations on so large an area places a tremendous responsibility on the State Forester.

Prior to the 1951 fire season each close-down order was applied on all forest operations in western Oregon. No practical plan had been devised to do otherwise. During the severe season of 1951, operations were closed down a number of times. In some instances all operations were halted within a fire district or two or three adjoining districts. In other instances close-down orders were imposed on all operations within a watershed. While this system was an improvement over that of previous years, many protests were registered by operators in certain areas where the fire danger was not particularly critical during the close-down period.

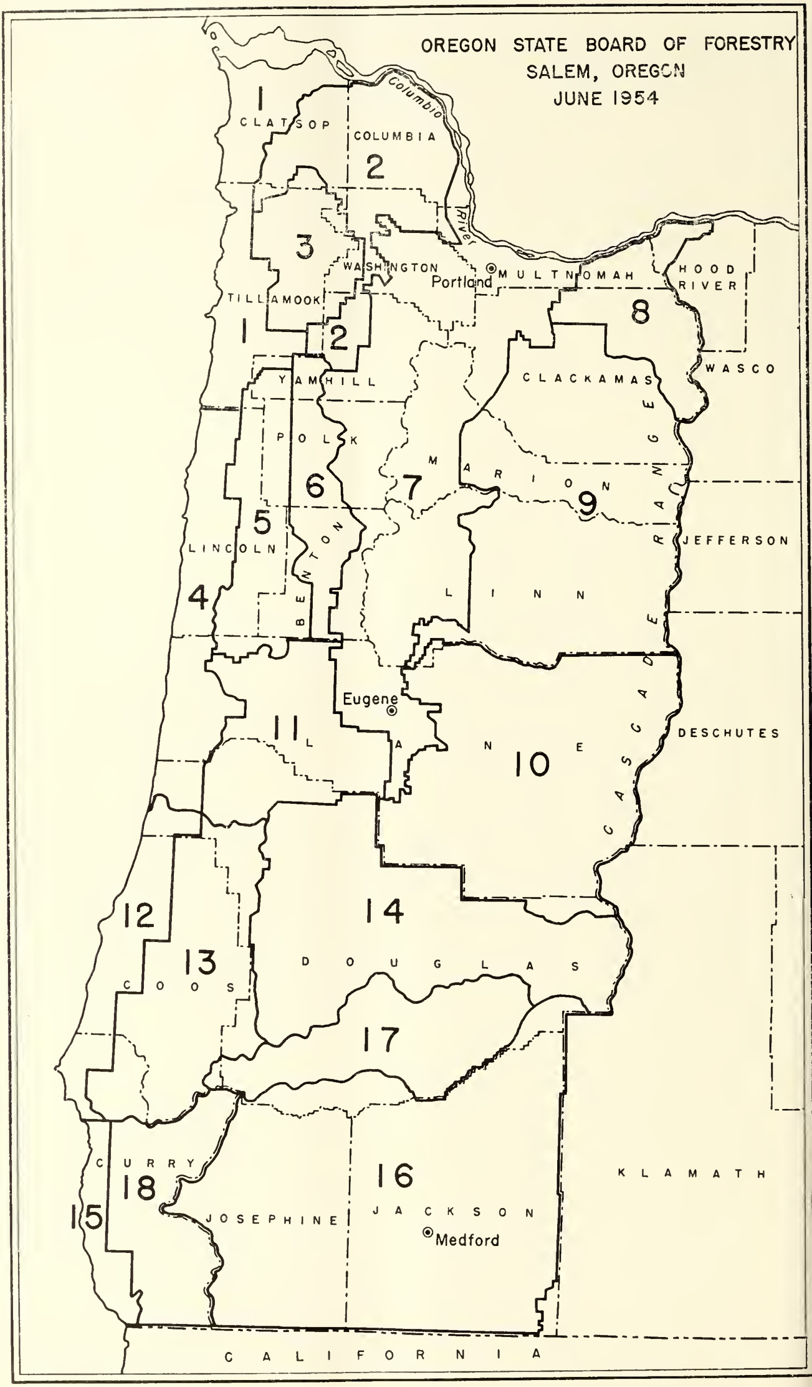

FIGURE 1.— Close-down zones in western O

During the latter part of the 1951 fire season the State Forester initiated a study of weather and hazard conditions on the area. This study consisted of reviewing weather statistics over a period of years, fire occurrence, fuel hazard such as unburned slash, logging activity, and the knowledge of local wardens. Information obtained definitely indicated that the western part of the State could logically be broken down into smaller areas for the purpose of administering the operation close-down feature of the law.

In 1952 western Oregon was divided into 16 close-down zones, each of which was considered to have a weather pattern of its own that at times might vary from the others. After the first year's experience, two zones were subdivided making 18 zones at the present time (fig. 1). These zones were established on the basis of fire weather, fuel types, operation activities, and administrative boundaries. This was done in order that the close-down periods could be applied as nearly as possible to areas affected by similar fire weather conditions.

In each zone several fire weather stations were established where fire weather data is taken throughout the day. This information is transmitted to the fire district headquarters office and from there radioed to the State Forester's office where it is tabulated for each zone. On the basis of this data, the judgment of the district warden in each zone of general burning conditions, and fire weather forecasts by the United States Weather Bureau, the determination is made of close-down periods for each zone.

Each operating permit issued by the State Forester shows the zone number for the area on which the operation is to be conducted. When a close-down order is issued, the operator need only look at his permit to determine if his operation is affected.

The State Forester may close one or as many zones as appears advisable according to conditions existing.

The United States Weather Bureau at Portland, Oreg., prepares fire weather forecasts by zones, twice daily. These forecasts are broadcast to all fire district headquarters offices over the forestry department's radio network and may be communicated to operators in the districts. During the critical period early in September 1955, operations were suspended in several zones without a single remonstrance from the operators affected. Further study is planned and if the information obtained indicates that changes in zone boundaries may be desirable or additional zones should be set up, these improvements will be made.

ROBIE CREEK FIRE SAFETY NEWS

[Editor's Note: Following is the text of a message prepared and distributed to fire overhead during the action phase of a project fire in the Intermountain Region of the U. S. Forest Service. The technique is worthy of consideration for wider use.]

TO ALL FIRE OVERHEAD:

Congratulations! Your SAFETY RECORD to date has been very commendable. In spite of very hazardous conditions, there have been no serious injuries on the Robie Creek Fire. To date, there have been three men disabled—one by a rolling rock, one due to an eye injury caused by running a branch into it, and another because of an insect flying into his ear.

However, with the fatigue factor now entering the picture, a danger of increasing accidents is more present. It is up to you, the overhead, from the Strawboss up to the Division Boss, to keep accidents from occurring. You are directly responsible for the safety of your men. *You cannot delegate this responsibility.*

FIRELINE SAFETY

The greatest fireline hazard on this fire is from falling snags, rolling rocks, and rolling logs. Be alert to these dangers. Keep lookouts posted for these dangers.

Make certain that every member of your crew knows his immediate boss.

Always have escape routes planned in advance. Remember that a burned-out area is the safest area during blowups.

Be careful of smoke inhalation.

Have your men drink water sparingly and use plenty of salt with their meals.

Immediately release all unsafe workers.

TRANSPORTATION

Do not transport men and tools in the same vehicle. Use your pickup for tools when you have trucks for men.

Designate one man in each truckload of men to insist upon the following:

a. Tools are not being carried with men.
b. Men are seated when truck is traveling.
c. Tailgates, or adequate roping, are used.

Truck drivers must keep a safe distance between vehicles because of smoke limiting visibility.

When traveling through burned areas, one man in the front with the driver must watch for dangerous snags and rolling material.

Depressing headlights, when traveling at night, often increases the visibility in smoky areas.

KEEP IT SAFE

J. M. MILLER, *Fire Boss*
GEORGE LAFFERTY, *Fire Safety Officer*

THE EFFECT OF CERTAIN VEGETATION ERADICATORS ON THE FLAMMABILITY OF VARIOUS MATERIALS[1]

E. J. WARD

Forestry Branch, Department of Northern Affairs and National Resources, Canada

The problem of vegetation eradication is one that confronts many organizations, among whom are railway companies. Their problem is that of reducing fire hazard by clearing potential fuels, such as shrub and herbaceous growth, from rights-of-way. These fuels could be ignited by live coals falling from a passing locomotive. Some chemical vegetation eradicators, however, have been suspected of providing a fire hazard themselves because of their flammable nature. It was also thought that they increase, temporarily, the flammability of vegetation and render railway ties more subject to burning and charring when contacted by hot coals.

In addition to studying the effectiveness of several herbicides, members of the Federal Forestry Branch conducted further tests at the Petawawa Forest Experiment Station in an effort to determine the effect on the flammability of materials with which these herbicides come in contact. For this latter project, railway ties and grass were used as flammability test media. No attempt is made here to assess the effectiveness of the chemicals as vegetation inhibitors.

STUDY TECHNIQUE

Stock solutions of the following herbicides were made up: Sodium chlorate, diesel oil, 2,4-D amine salt, 2,4-D butyl ester, 2,4,5-T, C.M.U., and Atlacide. Some of the concentrations were made stronger than those normally used so that poorly mixed solutions could be duplicated. (In order to reduce the effect of sodium chlorate solution in increasing the flammability of materials contacted, calcium chloride is sometimes added.) One quart of stock solution was used to spray each plot. To each quart of solution, except in the case of diesel oil, was added an extra quart of water. The extra liquid volume did not alter the amount of chemical used per square foot but did ensure more uniform plot coverage. The solutions were applied with an ordinary garden sprinkler can.

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[1]An article of this title appeared in its entirety in 1956 as Forestry Research Division Technical Note 36 of the Forestry Branch of the Canada Department of Northern Affairs and National Resources, Ottawa. A somewhat shortened version is published here through the courtesy of the Forestry Branch.

Tests involving railway tie and grass flammability were made on an open field on which all dead vegetation was burned off early in the spring in order to ensure a uniform coverage of green grass.

Twelve creosoted and 12 uncreosoted 6- by 8-inch softwood ties were used in the flammability tests. Four pairs of one-foot sections of each type were set on the ground in plots measuring 25 square feet each. One plot was sprayed with each type of herbicide. Similar grass-covered plots in the same location were sprayed with the same chemical vegetation inhibitors in order to determine their effect on the flammability of grass.

Matches were used as the ignition agents. First, one match was placed on the tie and ignited with another. If fire did not spread from the first, two matches were placed on the tie with their heads abutting. If only the matches burned, four were tried, and then eight. Flammability tests were made simultaneously on creosoted and untreated ties at intervals of 20 minutes, 1 day, 12 days, and 1 year after application of the chemical.

On the grass plots, attempts were made to burn plots representing each treatment at intervals of 5 minutes, 1 week, 1 month, and 1 year after spraying. Up to three matches were used for ignition. Again, as a control measure, untreated plots were tested at the same times.

TESTS ON RAILWAY TIES

In only a few cases were the results of tests made on creosoted and plain railway ties appreciably different. During tests made 20 minutes after treatment, only the plain ties treated with diesel oil and creosoted ties treated with diesel oil, C.M.U., or 2,4,5-T, appeared more flammable than the untreated ones. When ignited with one or more matches, fire spread across the surface of each of these more flammable ties. They were not damaged as seriously, however, as the untreated, plain tie which was deeply charred beneath the eight matches used in the test. During subsequent tests 1 day after treatment, ties sprayed with 20 percent sodium chlorate and 5 percent calcium chloride, and creosoted ties treated with diesel oil or 2,4-D butyl ester, appeared more flammable than untreated ties. Twelve days later, tests indicated that creosoted ties treated with 20 percent sodium chlorate and 5 percent calcium chloride or C.M.U., and plain ties treated with diesel oil, 2,4-D amine salt, 2,4-D butyl ester and 2,4,5-T, were more flammable.

After 1 year, only those ties treated with diesel oil, C.M.U., 5 percent solution of sodium chlorate, ammate, and 2,4,5-T, still indicated a slight tendency to burn, while the others showed no reaction. The degree of charring and fire spread was insignificant and occurred only near the matches. Of the ties treated with the first two solutions, the plain tie burned briefly, and on some of the creosoted ties treated with the latter three solutions, the creosote coating seemed to burn momentarily. No burning o

charring resulted from tests made on the remaining ties, including the untreated ones.

The only treatments which obviously increased flammability during the tests were diesel oil, strong solutions of sodium chlorate, 2,4-D butyl ester, and 2,4,5-T. The latter two caused only slight increase.

In no case was the charring of treated ties more serious than was evident on those untreated. In some instances, fire flashed over the surface of the tie causing ignition of surrounding herbaceous growth. This tendency was noted on ties treated with diesel oil and strong solutions of sodium chlorate, especially 1 day after treatment.

None of the solutions appeared to harm the ties through chemical action.

TESTS ON GRASS PLOTS

During flammability tests made on grass, none of the plots could be ignited 5 minutes after spraying except those treated with diesel oil and C.M.U. Grass treated with the former burned quite vigorously, but grass treated with the latter burned only an inch away from the igniting match. The untreated plot did not burn at all since, like other plots, it contained a very large percentage of green grass.

In tests made 1 week and 1 month after treatment, the relative flammability of the grass plots reflected to a great extent the percentage of grass killed by the chemical and the amount of accumulated dead material. One week after treatment, the plots treated with either Atlacide or a mixture of sodium chlorate and 2,4-D burned somewhat more vigorously than the percentage of green would indicate. Despite the fact that the ammate-treated plot was only 2 percent green, it burned less vigorously than would be normally expected. This may indicate that this chemical had a fire-retarding effect. Two other plots could be ignited briefly, but the fires were insignificant.

One month after treatment, plots treated with 2,4-D amine salt and 2,4,5-T were predominately green, but small fires were obtained on them. Test plots indicating very high or extreme flammability were those treated with 20 percent sodium chlorate and 5 percent calcium chloride, C.M.U. and Atlacide. On all of these plots, however, very little green grass remained. With very little dead vegetation existing on those treated with 2,4-D butyl ester and C.M.U., no fires were obtained. A very small fire burned briefly on the untreated plot.

One year after spraying, the flammability of plots coincided quite closely with the degree of kill and the amount of dead material on them. Test plots which had been treated with diesel oil showed a slightly increased flammability, but on the others any increase of fire activity could not be traced positively to the influence of the vegetation inhibitors applied to them.

SUMMARY AND CONCLUSIONS

In no case could it be definitely assumed that the chemical use actually reduced flammability.

The chemicals which most strongly exhibited a tendency t increase flammability were diesel oil and strong solutions o sodium chlorate. C.M.U. seemed to increase flammability slightl when the sprayed material was still wet. These observations hel true for each set of materials tested. Solutions of 2,4-D compound and 2,4,5-T raised flammability to a negligible extent in som cases.

Any advantages which may result from the use of diesel oi as a herbicide are offset by the increased flammability of mate rials so treated. Therefore, its use as a vegetation inhibitor coul not be justified where fire is not wanted. The same conclusio applies to strong solutions of sodium chlorate unless they ar mixed with calcium chloride in a ratio of at least two to on respectively. (It was observed in previous tests that the norma flammability of materials was actually reduced when treated wit a mixture of equal parts of the two chemicals.) It was clearl evident that 1 year after application none of the herbicides seri ously affected the flammability of either railway ties or grass.

In order to keep fire hazard to a minimum by avoiding a accumulation of dead material, it would seem advisable to do on of two things:

1. Before treatment, cut and burn grass and herbaceous growt in the autumn or early spring. Spray with herbicide during th development of new growth.

2. After treatment, burn the area when considerable brownin of the vegetation has become evident. This should be followed b a respray of the area since some new plant growth often appear

Following satisfactory killing of the vegetation on the treate area, it would be wise to maintain periodic spraying to preven the vegetation from becoming re-established and providing an other accumulation of fuel. Observations made to date on som of the herbicides would indicate that effective control would b maintained only if respraying was done at intervals not exceedin 3 years.

A TRAINING COURSE IN FIRE SAFETY AND FIRE SUPPRESSION TECHNIQUES

A. R. Cochran
Fire Control Chief, Region 7, U. S. Forest Service

Land managers face a training problem in common fire safety nd fire suppression techniques that must be met by the use of ive fire to demonstrate effectively fire's behavior and control. ctual fire conditions must be used, since today many district angers have had relatively little experience in fire control. Also, he oldtime cooperators with experience in fire fighting are being eplaced by a new generation with little background for this work.

To evaluate and to improve on this situation a regional training committee was appointed. This committee, consisting of a istrict ranger, an experienced ranger assistant, and a fire conrol specialist with administrative background, was to study trainng needs of the Region and to develop a fresh approach to training in fire safety and suppression.

The committee consulted with fire behavior experts in research nd others familiar with the reaction of fire to fuel, topography, nd weather at a specific time and location. They determined that nowledge of basic fire behavior is essential if fire fighters are to nderstand how natural forces influence fire in a given situation. lso fire behavior must be understood before men can anticipate nd meet problems of controlling fire safely and efficiently.

The committee's problem became that of finding an adequate ay to teach fire behavior so that the principles could be observed nd comprehended. The method of approach finally selected inolved 12 lessons arranged within the following three steps: (1) n introduction to fire behavior, since a fire control man must now fire behavior to do a good job of suppression. (2) The reparation of a fire suppression organization, which is conerned with the management of men, including their safety, elfare, and efficiency. (3) Actual fire suppression, which puts use the knowledge gained under (1), fire behavior, and (2), re suppression organization.

**Outline for a Course
in
How to Suppress a Forest Fire**

I. Introduction to fire behavior
   - A. How a fire burns (Lesson 1)
   - B. Heat transfer (Lesson 2)
   - C. Factors affecting combustion
     - 1. Fuel
       - a. Moisture content (Lesson 3)
       - b. Size and arrangement (Lesson 4)
     - 2. Weather (Lesson 5)
       - a. Wind
       - b. Moisture
     - 3. Topography (Lesson 6)

II. Fire suppression organization
   A. Use of tools (Lesson 7)
   B. Fire crew organization (Lesson 8)
   C. Line construction (Lesson 9)

III. Fire suppression
   A. Line location
      1. Factors in selecting point of attack (Lesson 10)
      2. Factors in securing the line—includes backfiring (Lesson 11)
   B. Mopup; fire out (Lesson 12)

The Region held a demonstration training session on Septem ber 11, 12, and 13, 1956, on the James River District of th George Washington National Forest. The trainees were youn technicians most of whom had been with the Service less than years. These men were divided into seven groups of seven eac with a national-forest fire staffman as instructor. In the beginnin the trainees were told that the course would test certain assump tions and training techniques and that each of them was to ap praise the effectiveness of the training in meeting the objective set up.

It is important that favorable burning conditions exist an that test fires do not burn too fast or too slowly for good in struction. Such conditions are indicated by the fire danger ratin or burning index. During the 3-day session favorable condition did exist as the 2:00 p. m. burning index showed:

Date:	*Buildup index*	*Fuel moisture (percent)*	*Wind (m.p.h.)*	*Burning index*
9/11	12	9.0	7.5	4
9/12	15	9.0	4.5	3
9/13	18	8.0	9.0	7

The first six lessons covered the subject of fire behavior. No until these were finished was there an attempt to apply fir behavior in fire suppression. These lessons were taught in a open field. Each group was equipped with a pile of sawdust— about 2 cubic yards in volume—for shaping into desired topo graphic features, a piece of tin about 3 feet square, a small suppl of light natural forest fuels, such as leaves, needles, twigs, an small limbs, and an adequate supply of planer shavings fo various tests in the lesson series.

Lesson 1, "How a fire burns," demonstrates in simple manne the four stages of combustion: (1) Preheating, (2) ignition, (3 gaseous combustion, and (4) carbon burning stage. If the piec of tin is bent into a U shape, and a small fire built underneatl fuel put on top of the tin will burst into flame without actuall coming in contact with a flame. This demonstrates preheating an gaseous combustion. The heat produced by combustion is im portant to understand and manage in fire control and is th subject for this lesson.

Lesson 2 demonstrates heat transfer by (1) radiation, (2 convection, (3) conduction, and (4) mass transfer. The lesso critique covers heat transfer not only by one method but also b a combination of two or more of these methods.

Lessons 3 through 6 develop the factors that affect combustion. Fuel moisture content is the most important variable affecting the combustion rate. Lesson 3 readily demonstrates this fact by using dry, normal, and green fuel of a given fuel type.

Lesson 4 demonstrates size and arrangement of fuel affecting combustion. The three sizes are light, medium, and heavy; and the four arrangements, loose, compact, continuous, and patchy.

Lesson 5 demonstrates and explains the factors of wind, moisture, and temperature.

In lesson 6 the final factor is demonstrated—topography as it affects the combustion rate. The information on behavior acquired by the trainee now enables him to tie in these factors with slope and shape. The effect of elevation and aspect are also explained. Interesting and realistic live fire demonstrations are possible with prepared fuel and appropriate topographic features shaped in the sawdust pile (figs. 1-4).

FIGURE 1.—The influence of topography brings about a characteristic two prong advance up the nearest spur ridges from the point of origin (planer shavings fuel).

FIGURE 2.—The steep valley between the ridges burns with great intensit at this stage of the development of this fire.

When the six basic fire behavior lessons have been complete the trainees should be able to apply the various factors accoun ing for behavior to particular situations or to set up assume situations and try them out on the sawdust pile. Many possibil ties exist for lively training situations, since with imaginatio and ingenuity they can be made interesting and realistic.

Lessons 7, 8, and 9 explain and demonstrate recruiting an organizing a fire crew, the crew's relation to the district or ganization, and its part in an expanded fire organization. The us of tools, here considered as a part of organizing a crew, is fo lowed by actual line construction in the field, including use o line fire in backfiring. The appropriate Safety Code provision of supervision, use of tools, transportation, and fire fighting for part of the instruction. A previously selected area having variety of fuel and topographic features is used. Low hills wit sharp relief and, of course, adequate fuel types produce the bes conditions for demonstration. The area should be mapped to sho topography and fuel and a map should be furnished each traine

FIGURE 3.—In this simulated situation the fire has burned to the top and is advancing downhill. (Straw chopped in 4-inch lengths is used for fuel.)

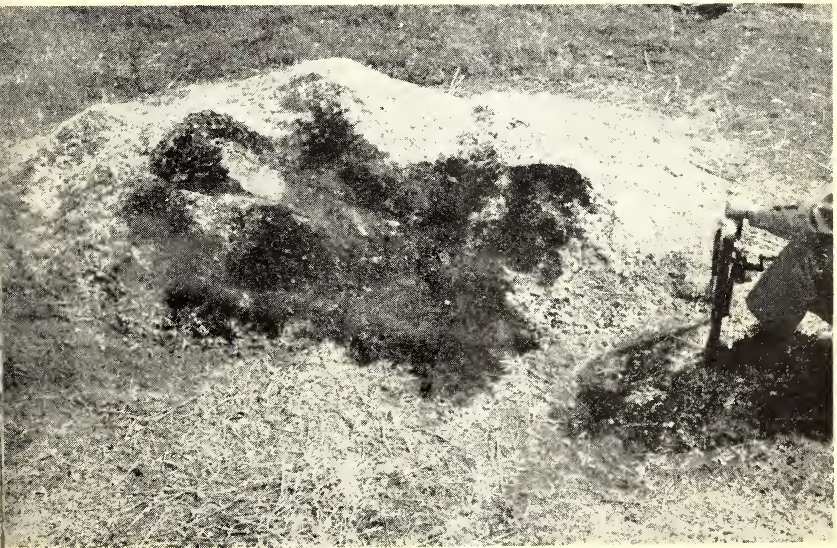


FIGURE 4.—Under the influence of a strong wind generated with a hand-operated fan, the fire travels across country. The influence of topography has been counteracted by that of wind (planer shavings fuel).

In lessons 10, 11, and 12 problems covering point of attack line location, and mopup are solved by demonstrating a variet of topographic and fuel situations. This is fire foremanship a work in applying fire behavior principles to the solution of fir problems. Live fire is used. A special mopup crew moves in an puts out the fires used in lessons 10 and 11 since mopup at thi point is not a part of the instruction.

Student performance was evaluated on the basis of FM 21-6— Techniques of Military Instruction, Department of the Army May 1954, Chapter 11. An examination consisted of 43 true-and false and multiple-choice problems. The scores for each of th seven groups were quite satisfactory, and ranged from 81 to 9 points out of a possible 99. The highest individual score was 93 and the lowest 67.

Trainee reaction and comments showed an enthusiastic en dorsement of this method of training in fire safety and fir suppression.

As a result of this test run, suggestions were obtained fro both trainees and committee critique for improving the subjec matter and for including certain introductory or supplementar material. These suggestions will be incorporated in revised lesso plans to provide more efficient instruction.

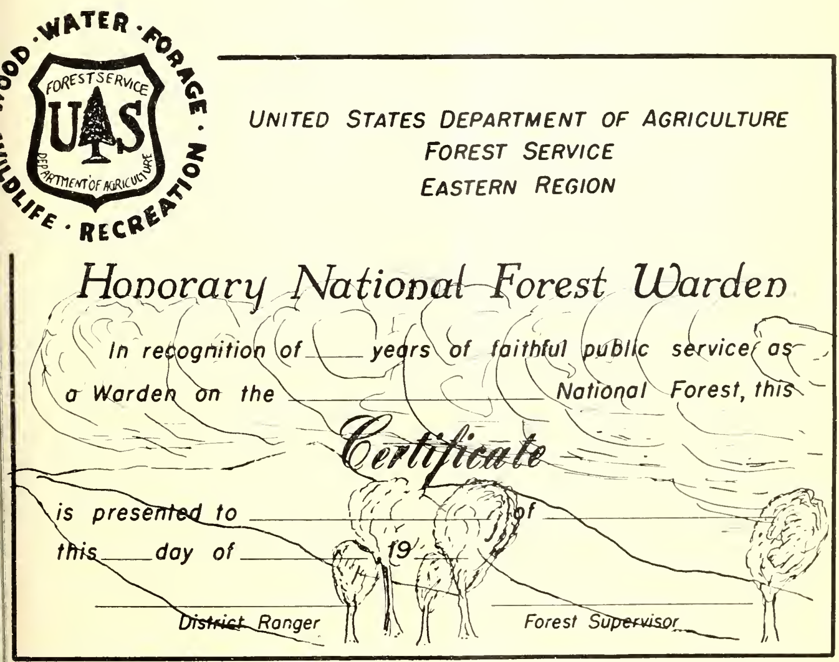
The 1956 session emphasized the value of complete plannin careful selection of instructors, and building a solid knowledge i fire fundamentals. From this point advanced training in overa fire safety and actual fire assignments can be approached wit greater confidence.

HONORARY NATIONAL FOREST WARDEN

A. R. Cochran
Fire Control Chief, Region 7, U. S. Forest Service

Forty-two years have passed since the first national forest wardens were organized in this Region. These wardens were pioneers and key individuals in establishing fire protection. The group was founded as a ready force to defend the country's forests from fire. Most of the oldtimers have been replaced by members of a new generation, but these pioneers remain an active and important influence behind the warden organization.

When the fire crew leaders reach an age where strenuous fire fighting is not good practice, they can still serve well in fire prevention work. Their experience, training, and standing in the community are strong factors in promoting fire prevention. Most wardens want to feel that they are still a part of the protection force and are needed. If appropriate recognition is given, such as by appointing them Honorary Wardens, their continued interest and leadership is retained.


WOOD · WATER · FORAGE · WILDLIFE · RECREATION
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
EASTERN REGION

Honorary National Forest Warden

In recognition of ____ years of faithful public service as a Warden on the ____________ National Forest, this

Certificate

is presented to ____________ of ____________
this ____ day of ____________ 19__

____________ District Ranger ____________ Forest Supervisor

Figure 1.—Honorary national forest warden certificate.

The national forests in Region 7 have been quite successful i making the transition from warden to honorary warden. Th ranger who promoted the idea held a special dinner at which h presented the "graduating" wardens with honorary certificate prepared especially for the occasion (fig. 1). The press wa invited and obtained interesting life stories, featuring battle in the early days to protect the country's resources.

Now it has become standard practice to mark such occasion with ceremony. The retiring warden is presented with a regiona honorary warden certificate, appropriately framed, which be comes a prized keepsake because of its association.

FIGURE 2.—Rustic routed honorary warden sign on the Jefferson Nation Forest.

A routed rustic sign honoring the warden is being used c the Jefferson National Forest (fig. 2). This has been well r ceived. To have an active trained warden organization is goo business, but it is also good business to retain the interest an backing of the oldtimers who have played an active part i resource conservation.

OCCURRENCE RATE AS A MEASURE OF SUCCESS IN FIRE PREVENTION

JOHN J. KEETCH

Forester (Fire Control), Division of State and Private Forestry, Region 7, U. S. Forest Service

There is a direct relation between Burning Index, as measured y meter type 8 in the Northeast, and fire occurrence. This is lustrated by the following tabulation of data from District 3, in ıe northern piedmont of Virginia, for calendar year 1954.[1]

Burning Index range:	*Days (number)*	*Fires (number)*	*Rate of fires per day*
0-10	164	15	0.1
11-20	88	42	.5
25-40	70	72	1.0
45-80	37	113	3.1
85+	6	38	6.3
Total	365	280	—

The number of fires per day for similar burning conditions aries greatly among districts because of differences in size, seaonal risk, and population trends. However, an increase in fire ıcidence with an increase in Burning Index, such as in Virginia istrict 3, is common throughout the Eastern Region. This means ıat wide fluctuations in fire weather from year to year are sually accompanied by similar fluctuations in fire occurrence. 'hus, unless the effect of changing weather on fire occurrence is ccounted for, it is impossible to judge whether we are gaining r losing in fire prevention. As an example, District 3 averaged 50 fires per year during the 6-year period 1943-48, and 254 fires er year for the 6-year period 1949-54. Corresponding figures for ıe State of Virginia are 1,888 fires and 2,151 fires. Such increases ı the average occurrence are most discouraging, especially when re prevention effort has been greatly strengthened and expanded ince 1943. An obvious inference is that more severe burning conitions during the latter period increased the average fire occurence. Although this is a reassuring thought, it does not prove ıe effectiveness of the fire prevention program, because the fact emains, more fires occurred.

A clearer view of the situation is to compare the annual occurence to measured fire danger to determine whether the occurence rate (number of fires per thousand units of Burning Index) rising or falling. A decrease in the occurrence rate, especially a downward trend is maintained for a period of years, would e tangible evidence of success in fire prevention.

[1]Data summarized from table 6, 1954 Forest Fires and Fire Danger in irginia, by J. J. Keetch and M. C. Gladstone, mimeographed report, Southst. Forest Expt. Sta., December 1955. Selected as being fairly representave of the 68 analysis units in Region 7.

This is illustrated in figure 1 for District 3, Virginia. In th
upper graph the total fires and total Burning Index (in thousand
of units) are plotted by years 1943-54, the period for which com
plete records are available. The occurrence rate for correspondin
years is shown in the lower graph. Although the number of fire

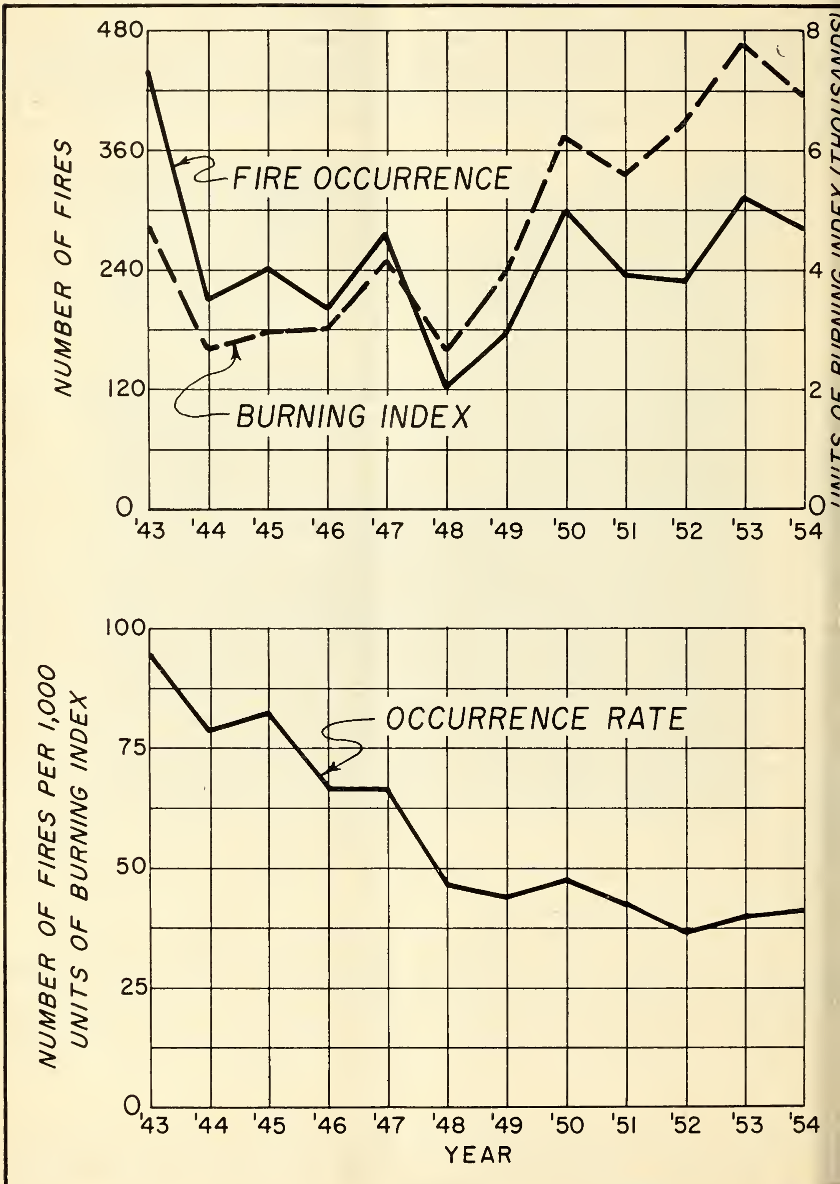
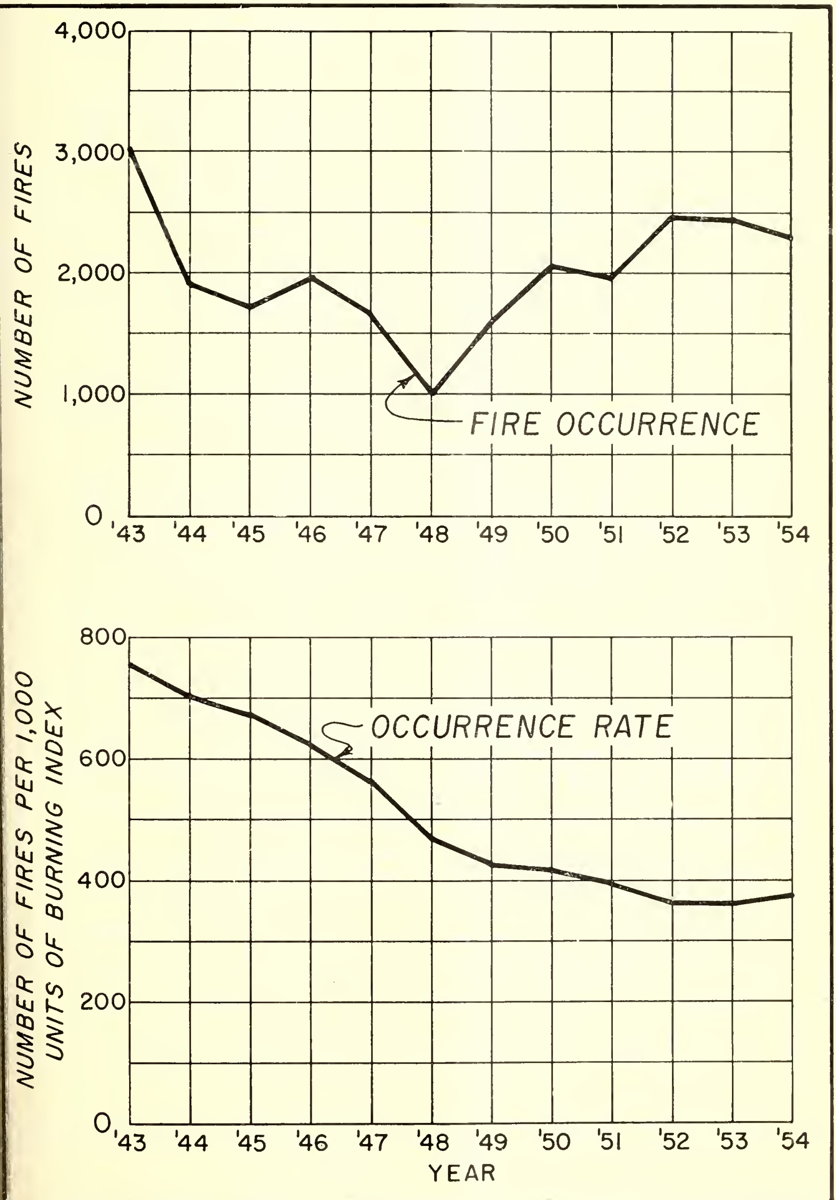


FIGURE 1.—Fire occurrence, Burning Index, and occurrence rate in Distr
3, Virginia, by years, 1943-54.

aried greatly—from 448 fires in 1943 to 120 fires in 1948, then ack to 311 fires in 1953—the occurrence rate shows a fairly consistent downward trend.

Just as the number of fires by districts may be added to derive he total State occurrence, the district occurrence rates may be



IGURE 2.—Fire occurrence and occurrence rate in Virginia, all districts, by years, 1943-54.

added to obtain a figure representing the statewide rate. This procedure is illustrated in figure 2, which shows the district totals for the 9 administrative districts in Virginia, 1943-54. After the 1948 season the State Forester could view the downward trend

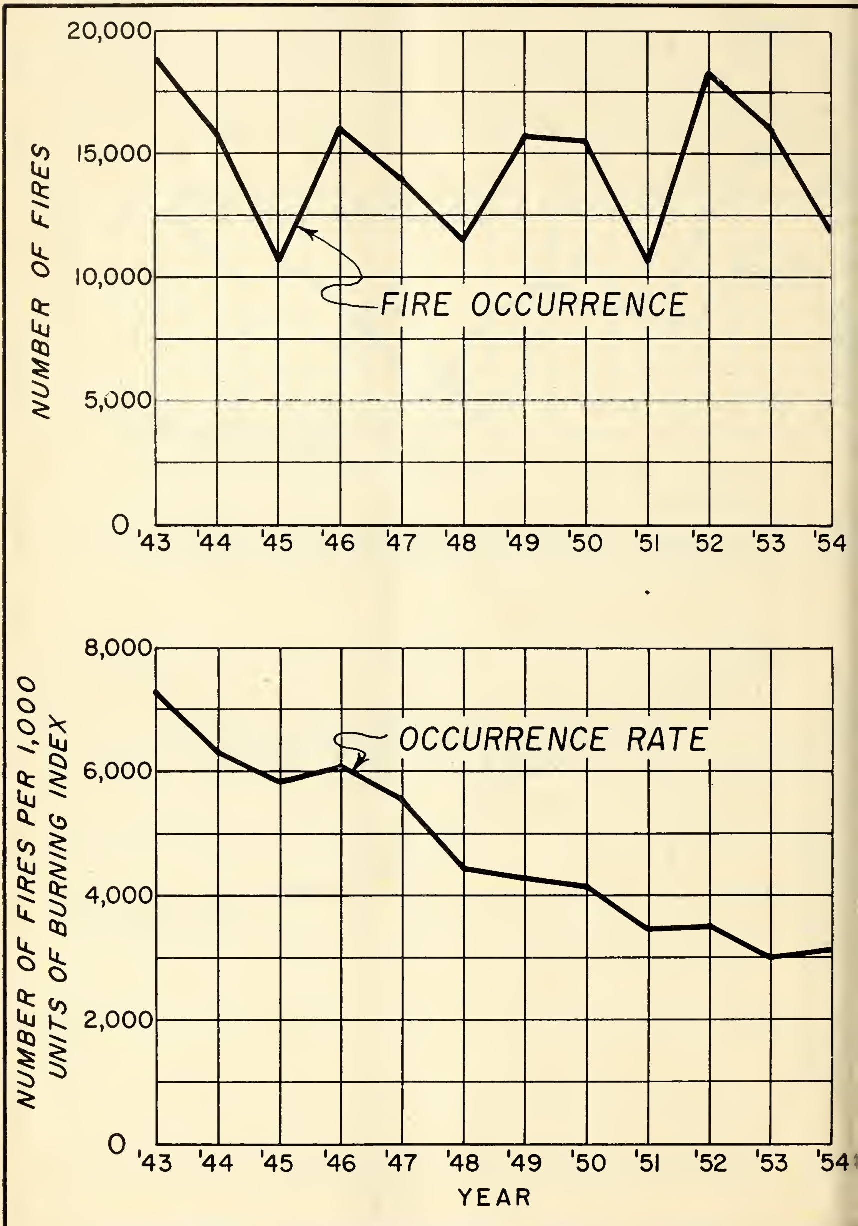


FIGURE 3.—Fire occurrence and occurrence rate in the States of Region 7 except Delaware, by years, 1943-54.

n number of fires since 1943 with considerable satisfaction. How-
ver, at the end of the 1954 season he could probably find little omfort in viewing the persistent high level of occurrence since 948. It all depends from what point in time he chose to evaluate he preceding years of record. The data on occurrence rate in he lower section of figure 2 removes any doubt that the occurrence ate in Virginia, statewide, has been decreasing whether viewed rom 1948 or 1954.

Just as the district data build up to State totals, so the State ata build up to regional totals. The regional data on number of res and occurrence rate are shown in figure 3.[2] Regionwide, it vould be difficult to claim any success in reducing the number of ires if the top graph in figure 3 is the extent of the record. A rend line averaging the 12-year period would be just about level. 'he true picture unfolds in the lower graph, where it is evident hat the occurrence rate for the last 5 years of the period is much ower than for the first 5 years. The computed reduction based n averages for the two 5-year periods is 44 percent—a definite neasurement of success in fire prevention when the effect of veather has been considered. Such a statement is more con- incing and is much more useful in fire control planning than to ay, "Sure, we are having about the same number of fires as we id 10 years ago, but then, we have more people in the woods and he weather has been worse."

[2]Fires that occurred on days when the fire danger was not measured re not included. Occurrence in Kentucky was adjusted to the 1954 protected rea level. Occurrence in Massachusetts was adjusted to the 1953 and 1954 vel of reporting.

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

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PREVENT FOREST FIRES!

VOL. 18 APRIL 1957 No. 2

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 18 Number 2

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

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Forest Service, Washington, D. C.

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CONTENTS

SOME PRINCIPLES OF COMBUSTION AND THEIR SIGNIFICANCE IN FOREST FIRE BEHAVIOR

GEORGE M. BYRAM
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Combustion chemistry

Although a large fire is essentially a physical or meteorological phenomenon, combustion itself is a chemical chain reaction process, which takes place at high temperatures. In all forest fires, large or small, materials such as leaves, grass, and wood combine with oxygen in the air to form combustion products plus large quantities of heat. Heat, as we shall see, is the most important combustion product in fire behavior.

There are three rather definite phases of combustion, although they overlap somewhat and all exist simultaneously in a moving fire. First comes the preheating phase in which fuels ahead of the fire are heated, dried, partially distilled, and ignited. In the second phase, the distillation of gaseous substances continues but is now accompanied by their burning or "oxidation." Ignition might be regarded as the link between the first, or preheating, phase and the second, or gaseous, combustion phase. Ignition may also be regarded as the beginning of that part of the combustion process in which heat is given off. The flames seen over a forest fire or in a fireplace are the burning of distilled gases; combustion products are principally invisible water vapor and carbon dioxide. If combustion is not complete, some of the distilled substances will condense without being burned and remain suspended as very small droplets of liquid or solid over the fire. These condensed substances are the familiar smoke that accompanies most fires. Under certain conditions some of the water vapor may also condense and give the smoke a whitish appearance.

In the third or final phase the charcoal left from the second phase is burned and leaves a small amount of residual ash, which is not a combustion product. If combustion is complete and if the charcoal[1] is mostly carbon, the primary combustion product in this phase will be carbon dioxide because the initial water is driven off in the first two phases. Some carbon monoxide is formed as an intermediate product which in turn burns as a gas to form carbon dioxide. The small blue flames appearing over the coals in a fireplace are carbon monoxide burning. However, if combustion is not complete, small amounts of carbon monoxide remain. In this phase the fuel is burned as a solid, with oxidation taking place on the surface of the charcoal.

Even though the three combustion phases tend to overlap, they can be plainly seen in a moving fire. First is the zone in which leaves and grass blades curl and scorch as they are preheated by the oncoming flames. Next is the flame zone of burning gases.

[1]The composition of charcoal varies, depending on the conditions under which it is formed. If the distillation temperature is low, 400 to 500° F., the charcoal will contain considerable tar coke. However, in the rapid heating and resultant high temperatures existing in a forest fire, the deposits of secondary products in the charcoal are probably low.

Following the flames is the third but less conspicuous zone o burning charcoal. Unless fuels dry to a considerable depth (tha is, unless the Build-up Index is high), this last zone may be al most absent. If this happens the burned-over area will appea black instead of gray, which means that much of the remainin charcoal, as well as some of the underlying fuel, has not com pletely burned. With the exception of such years as 1947, 1952 and 1955, a blackened burned-over area has been more commo than a gray ash-covered area in the Eastern and Southern States

Heat of combustion

The heat of combustion is heat that makes combustion a chai reaction. Heat supplied to unburned fuel raises its temperatur to the point where the fuel, or the gases distilled from the fue can react with the oxygen in the atmosphere and in so doing giv off more heat. This in turn raises the temperature of adjacen fuel, and thus the chainlike nature of combustion becomes es tablished.

The heat energy released by burning forest fuels is high an does not vary widely between different types of fuels. The tabula tion below gives the heats of combustion for a number of sub stances. These materials and heats were selected from tables i Kent's *Mechanical Engineers Handbook*, 12th edition. The average is probably a good approximation for forest fuels. Fue do not ordinarily burn with maximum efficiency, so the actua amount of heat released per pound of fuel in a forest fire will b somewhat less than shown in the tabulation. For a small fir burning in dry fuels with very little smoke, the combustio efficiency might be as high as 80 percent. Large fires burning wit dense smoke would be less efficient. Combustion efficiency probab drops somewhat with increasing moisture content.

Substance:	*Heat of combustion per pound, d (B.t.u.)*
Wood (oak)	8,316
Wood (beech)	8,591
Wood (pine)	9,153
Wood (poplar)	7,834
Pine sawdust	9,347
Spruce sawdust	8,449
Wood shavings	8,248
Pecan shells	8,893
Hemlock bark	8,753
Pitch	15,120
Average (excluding pitch)	8,620

Heats of combustion are given in British thermal units p pound of dry fuel. A B.t.u. is the quantity of heat needed to rai the temperature of 1 pound of water 1° F. For example, the abo tabulation shows with the help of a little arithmetic that t burning of 1 pound of an average woody fuel gives off enou heat to raise the temperature of 100 pounds of water about 86° To raise the temperature of 100 pounds of water (about gallons) from a temperature of 62° F. to the boiling temperatu of 212° F. would require about 1.7 pounds of an average woo

'uel if it burned with maximum efficiency. About 1 pound of pitch vould accomplish the same result.

The rate of heat release in a forest fire can be visualized by :omparing it with a familiar rate, such as that required for house ieating. For example, consider a hot, rapidly spreading fire)urning with a 20-chain front and with a forward rate of spread)f 50 chains per hour. If the fire burns 6 tons of fuel per acre, n 1 hour's time enough fuel would be consumed to heat 30 iouses for a year if each house yearly required the equivalent of l0 cords of wood weighing approximately 2 tons per cord. Oc- :asionally there is a fire in the Eastern States with a rate of spread exceeding 5,000 acres per hour. If it burns in a dense, :ontinuous stand of conifers, which might have 12 tons or more)f available fuel per acre, such a fire could consume enough fuel n an hour to heat 3,000 houses for a year.

Heat transfer

There are three primary ways in which heat travels or is ransferred from one location to another. These are conduction, :onvection, and radiation. Although dependent on convection, here is a fourth or secondary means of heat transfer in forest ires, which might be described as "mass transport." This is the arrying of embers and firebrands ahead of the fire by convective urrents and results in the familiar phenomenon of "spotting."

As a heat-transfer mechanism, conduction is of much greater mportance in solids than in liquids and gases. It is the only way eat can be transferred within opaque solids. By means of con- uction, heat passes through the bottom of a teakettle or up the andle of a spoon in a cup of hot coffee.

Convection is the transfer of heat by the movement of a gas r liquid. For example, heat is transferred from a hot air furnace ito the interior of a house by convection, although the air picks p heat from the furnace by conduction.

Radiation is the type of energy one feels when sitting across ie room from a stove or fireplace. It travels in straight lines like ght, and it travels with the speed of light.

Most of the preheating of fuels ahead of a flame front is done y radiation. For a fire that occupies a small area and can be iought of as a "point" (such as a small bonfire or a spot fire), ie intensity of radiation drops as the square of the distance from ie fire increases. For example, only one-fourth as much radiation 'ould be received at 10 feet as at 5 feet from the fire. However, hen a fire becomes larger, the radiation intensity does not drop f so rapidly. For a long line of fire, the radiation intensity drops s the distance from the fire increases; that is, one-half as much idiation would be received at 10 feet as at 5 feet. For an ex- nded wall of flame, radiation intensity drops off even more owly. This tendency for radiation to maintain its intensity in ont of a large fire is an important factor in the rapid growth f a fire's energy output.

Convection, with some help from radiation, is the principle eans of heat transfer from a ground fire to the crowns of a

conifer stand. Hot gases rising upwards dry out the crown canopy above and raise its temperature to the kindling point. Althoug convection initiates crowning, both convection and radiation pre heat the crown canopy ahead of the flames after a crown fire i well established. Convection is also a factor in the preheating o the ground fuels in a surface fire but to a lesser extent tha radiation. The effects of both radiation and convection in pre heating are considerably increased when a fire spreads upslope because the flames and hot gases are nearer the fuels. The op posite is true for downslope spread.

Convection and radiation can transfer heat only to the sur face of unburned (or burning) fuel. Actually, radiant heat ma penetrate a few thousandths of an inch into woody substance and this penetration may be of some significance in the burnin of thin fuels, such as grass blades and leaves. However, radiatior like convection, for the most part transfers heat only to th surface of fuel material, and conduction may be considered th only means of heat transfer inside individual pieces of fuel. Fo this reason conduction is one of the main factors limiting th combustion rate in heavy fuels, such as slash and limbs and log in blowdown areas. Materials that are poor conductors of hea such as most forest fuels, ignite more readily than do good co ductors, but they burn more slowly. Although the effects c conduction are far less conspicuous than those of radiation an convection, conduction is a very important factor in the com bustion process.

Factors affecting the combustion rate

Many factors affect combustion in such complex ways th they are not yet fully understood even for a simple gas or liqu fuel. Solid fuels are even more complex. Even so, there are tv rather simple factors that have obvious and definite effects on tl combustion rate of woody substances and are of great importan in forest fire suppression. The first of these is the moisture conte of the fuel, and the second is fuel size and arrangement.

It is difficult to overestimate the effect of water on the co bustion rate and, hence, on fire behavior. Water in a fuel great diminishes the preheating rate in the first phase of combustic Much of the heat is used in raising the temperature of the wat and evaporating it from the fuel. The large quantities of resulti water vapor dilute the oxygen in the air and thus interfere wi the second or gaseous combustion phase. If the initial fuel moistu is high enough, water vapor may make the mixture so "lea that the gases will not burn. This dilution of the oxygen in t air also affects the third or carbon-burning phase of combustic Although data are lacking, it is probable that moisture reduc considerably the heat yield or combustion efficiency. This h loss would be in addition to that resulting from the water-heati and evaporation requirements.

The effect of size and arrangement of fuel on combustion c be illustrated by the following example. Consider a large pile dry logs all about 8 inches in diameter. Although somewhat di

cult to start, the log pile will burn with a hot fire that may last for 2 or 3 hours. The three primary heat-transfer mechanisms are all at work. Radiation and convection heat the surfaces of the logs, but only conduction can transfer heat inside the individual logs. Since conduction is the slowest of the three heat-transfer mechanisms, it limits the combustion rate in this case. Consider now a similar pile of logs that have been split across their diameters twice, or quartered. Assume that the logs are piled in an overall volume somewhat greater than the first pile, so there will be ample ventilation. This log pile will burn considerably faster than the first one because the combustion rate is less dependent on conduction. The surface area was more than doubled by the splitting, so that convection and radiation are correspondingly increased in the preheating effects. The burning surface is also increased by the same amount.

Assume that the splitting action is continued indefinitely until the logs are in an excelsior state and occupy a volume 30 or 40 times as great as in their original form. Convective and radiative heat transfer will be increased tremendously in the spaces throughout the whole fuel volume, and the combustion rate might be increased to a point where the fuel could be consumed in a few minutes instead of hours.

The effect of fuel arrangement can be visualized if a volume of excelsiorlike fuel, such as that just described, is compressed until it occupies a volume only 4 or 5 times that of the original volume of logs. The total burning surface and radiative conditions remain the same as before compression, but both convective heat exchange and oxygen supply are greatly reduced. There will be a corresponding decrease in fire intensity.

Fuel size and fuel arrangement have their greatest effect on the lower intensity fires and in the initial stages of the buildup of a major fire. When a fire reaches conflagration proportions, the effect on fire behavior of factors such as ignition probability and quantity of firebrand material available for spotting may be greater than the effect of fuel size and arrangement. This point will be discussed in the section on applications to fire behavior.

The fire triangle

The principles of combustion may be summarized in an effective way by means of the fire triangle. This triangle neatly ties together not only the principles of combustion but illustrates their application as well. The three sides of the triangle are FUEL, OXYGEN, and HEAT. In the absence of any one of these three sides, combustion cannot take place. The fire triangle represents the basic link in the chain reaction of combustion (fig. 1). Removing any one or more sides of the triangle breaks or destroys the chain. Weakening any one or more sides weakens the chain and diminishes fire intensity correspondingly. The purpose of all fire suppression efforts is to remove or weaken directly or indirectly one or more sides of the fire triangle. Conversely, all conditions that increase fire intensity operate in such a way as to greatly increase or strengthen the sides of the triangle and, hence, the chain

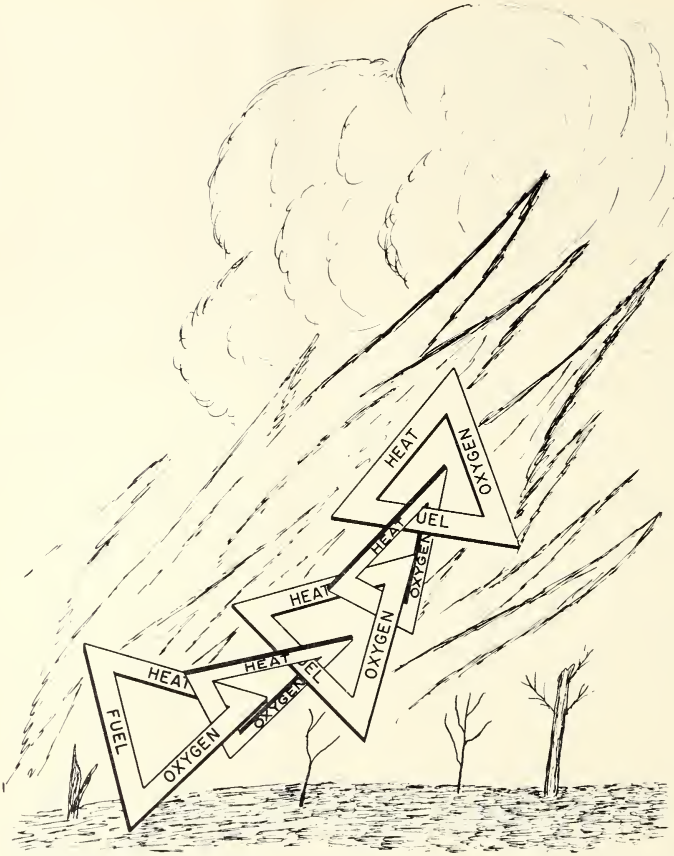

FIGURE 1.—The fire triangle is the basic link in the chain reaction o combustion.

reaction of combustion. In a blowup fire the chain becomes so strong that it cannot be broken by the efforts of man. This means that when blowup conditions exist, the only opportunity to breal the chain is by early strong initial attack.

Application to fire behavior

It is more difficult to apply our knowledge of ignition anc combustion to the behavior of very high-intensity fires, sometime referred to as conflagrations or "blowups," than to the behavio of the more frequent low-intensity fires. The ordinary fire behave for the most part as one would expect from the principles o combustion. In a conflagration or blowup, however, the sides o the fire triangle are greatly strengthened by factors that ar absent, or nearly so, in small fires. Although these factors worl through the basic combustion principles, they so greatly modif the expected effects of the basic processes that a high-intensit erratic fire cannot be considered as a large-scale model of a low-intensity fire. This is best illustrated by considering th

spatial structure of the two types of fires. The height of the significant vertical structure of a low-intensity fire can usually be expressed in tens of feet. This distance is usually small compared to the surface dimensions of the burning area, so that in a physical sense the fire is "thin" or 2-dimensional as far as volume structure is concerned. On the other hand, the significant vertical structure of a well-developed conflagration may extend thousands of feet into the air, and this dimension may at times exceed the surface dimensions of the burning area.

The height that smoke rises above, or in the neighborhood of, a fire is not always a true indicator of the height of the active convection column above a fire. Smoke from a small fire may reach a height of 1,000 feet or more, but active convection may reach only a few percent of this height.[2]

It is the 3-dimensional structure of a large fire that causes it to take on storm characteristics which, in turn, produce behavior phenomena that one could not expect by scaling upwards the behavior of a low-intensity fire. However, this does not mean that scale-model fires, including small fires in the laboratory under controlled conditions, would not be useful in preliminary convection column studies. Probably experimental work on convection column properties should be started first on small scale fires. Such work might give essential fundamental information on the relation between the variables controlling the convection process.

Certain properties of the atmosphere, such as the vertical wind profile and to a lesser extent the vertical temperature profile, appear to be the controlling factors in extreme fire behavior if an extensive area of plentiful dry fuel exists. A discussion of the atmospheric factors is outside the scope of this paper, but it may be well to examine in some detail those phases of the combustion process that permit the atmospheric factors to exert their maximum effect.

Fire behavior is an energy phenomenon and its relation to the combustion process can be understood by the use of four basic fuel factors relating to energy. These are (1) combustion period, (2) critical burn-out time, (3) available fuel energy, and (4) total fuel energy. This last factor is constant, or nearly so, for any given quantity of fuel per acre. The first three are variables which, even for any homogeneous component in a given fuel type, depend on factors such as fuel moisture content and fire intensity. A fifth fuel factor, the quantity of firebrand material available for spotting, is more or less independent of the other four and will be treated separately.

The combustion period may be defined as the time required for a fuel to burn up completely, and depends primarily on fuel size, fuel arrangement, fire intensity, and fuel moisture. It may range from a few seconds for thin grass blades to several hours or longer for logs and heavy limbs. Critical burn-out time is defined as the maximum length of time that a fuel can burn and

[2]Although it is too involved to discuss in a paper on combustion, the height of the convection zone depends on the rate of heat output of the fire, the wind speed, the vertical wind shear, and the stability of the atmosphere.

still be able to feed its energy into the base of the forward traveling convection column; its magnitude depends primarily on fire intensity or the rate of a fire's energy output. The available fuel energy is that part of the total fuel energy which is fed into the base of the convection column. For fuels with a combustion period equal to or less than the critical burn-out time, the available fuel energy is equal to the total fuel energy. If the combustion period is longer than the critical burn-out time, then the available fuel energy is less than the total fuel energy. Total fuel energy is determined by the quantity of fuel per acre and the combustion efficiency. If the combustion efficiency is assumed to be constant, the terms "available fuel energy" and "total fuel energy" can be replaced by the terms "available fuel" and "total fuel."

An example will illustrate how fire behavior relates to the four preceding quantities. Consider a fire spreading in an area of plentiful heterogeneous fuel, a considerable part of which is in the form of flammable logs and heavy slash and the rest a mixture of smaller material such as twigs, pine needles, and grass. Assume that the critical burn-out time is about 20 minutes. Those fuel components with a combustion period less than 20 minutes will have an available fuel energy equal to their total fuel energy. However, logs and heavy limbs may require several hours to burn out, so their available energy may be comparatively low; they could still be burning after the fire had moved several miles, so would not be affecting the behavior of the fire front.[3] From the standpoint of fire behavior, a crown fire in a dense conifer stand could have more available fuel energy than a fire in an area of heavy logging slash. However, unless large portions of a heterogeneous fuel have very long combustion periods, fuel size and fuel arrangement should not have as much influence on the behavior of major fires as on smaller fires. In a major fire a larger proportion of the heavier fuels take on the characteristics of flash fuels. This is a combined result of the shorter combustion periods and longer critical burn-out times for the high-intensity fires. Nevertheless, fuel size and fuel arrangement contribute heavily to the rate of buildup of fire intensity, especially in the early stages, and are therefore an important part of the fire behavior picture.

Much of the effect of fuel moisture can be interpreted in terms of the four basic fuel factors. Because moisture decreases the combustion rate, it increases the length of the combustion period. This, in turn, means that a smaller fraction of a heterogeneous fuel will have a combustion period less than the critical burn-out time. The available fuel energy and fire intensity will, therefore, drop as fuel moisture increases. For most fires there are some fuel components which do not burn because of their high moisture content; in other words, these components may be regarded as having infinitely long combustion periods.

[3]Heat sources a considerable distance behind the main flame front could possibly have indirect effects on fire behavior by slightly modifying the structure of the wind field.

An increase in fire intensity can greatly reduce the combustion period for those fuel components with the higher moisture contents. For some components the combustion period might be infinite for a low-intensity fire, but perhaps only a few minutes, or even less, for a high-intensity fire. For example, in the high-intensity Brasstown fire on March 30, 1953, in South Carolina, as well as in other large fires in the Southeast in the last few years, green brush often burned leaving blunt pointed stubs. In a similar manner a reduction of the combustion period from infinity to a few seconds for green conifer needles takes place when a fire crowns.

The fifth fuel factor, the quantity of firebrand material available for spotting, becomes increasingly important as fire intensity increases. Equally important is the relation between surface fuel moisture and the probability of ignition from embers or firebrands dropped from the air. This relation has not as yet been determined experimentally, but ignition probability increases rapidly with decreasing fuel moisture—hence with decreasing relative humidity. We know that the ignition probability for most firebrands is essentially zero when fuel moisture is 25 or 30 percent (on an oven-dry weight basis). We also know that not only ignition probability but combustion rate as well is greatest for oven-dry material. In addition, both of these phenomena in the lower moisture content range appear to be considerably affected by a change of fuel moisture content of only a few percent.

The importance of the relation between fuel moisture and ignition probability in the behavior of large fires can be illustrated by a hypothetical example. Suppose that from the convection column over a large fire, 10,000 embers per square mile per minute are dropping in front of the fire. Suppose that the surface fuel moisture content is such that only 0.1 percent of these firebrands catch and produce spot fires, thus giving only 10 spot fires per square mile. On the other hand, if we assume that the surface fuel moisture is low enough for 5 percent of the embers to catch, then there would be 500 spot fires per square mile. As they burn together, these spot fires would greatly increase the rate of spread and intensity of the main fire. Thus, relative humidity (working through fuel moisture) has a 2-fold effect on rate of spread in certain types of extreme fire behavior. First is the effect on fuel combustion rate and rate of spread of the ordinary flame front. This effect would be present on small and large fires alike. Second is the effect in accelerating rate of spread and fire intensity by increasing the probability of ignition from falling embers. This latter effect would be present only on fires where spotting was abundant. Ignition probability will also depend on other factors, such as the nature of the surface fuel in which firebrands fall and the fraction of the ground area covered by the fuels.

Fuel characteristics that make plentiful and efficient firebrands are not definitely known. The material would have to be light enough to be carried aloft in updrafts, yet capable of burning for several minutes while being carried forward by the upper winds. Decayed punky material, charcoal, bark, clumps of dry duff, and

dry moss are probably efficient firebrands. Leaves and grass are more likely to be inefficient firebrands except over short distances.

The initial phases of the blowup phenomenon are directly related to the combustion process and the basic fuel factors. A decreasing fuel moisture means higher combustion rates and shorter combustion periods. There will, therefore, be an increase in the available fuel energy, or available fuel, accompanied by an increase in fire intensity. The increase in fire intensity lengthens the critical burn-out time which means a further increase in available fuel. A cycle of reinforcement is thus established which favors growth of fire intensity. As the intensity increases, the atmospheric factors become increasingly important. It is at this stage that spotting and ignition probability may become dominant fire behavior factors.

By using the basic fuel factors it is possible that a fuel classification method could be developed to classify fuel in terms of expected fire behavior. It would first require a series of burning experiments to measure some of the factors and their response to variables such as moisture content and fire intensity. However, once this was done, the classification system itself might be comparatively simple. Probably its greatest value would be in estimating the conflagration potential of different fuel and cover types for different combinations of weather conditions.

There is an important difference in the energy conversion process for a low-intensity fire and a high-intensity fire. In the "thin" or 2-dimensional fire, most of the energy remains in the form of heat. At the most, such a fire cannot convert more than a few hundredths of one percent of its heat energy into the kinetic energy of motion of the updraft gases and the kinetic energy of the convection column eddies.[4] On the other hand, a major conflagration may convert 5 percent or more of its heat energy into kinetic energy which appears in the form of strong turbulen updrafts, indrafts, convection column eddies, and whirlwind which can carry burning material aloft. The efficiency of th energy conversion process, and hence the kinetic energy yield increases rapidly with increasing fire intensity. This is brough about by the mutual reinforcement action in the basic fuel factor plus favorable atmospheric conditions.

In addition to the difference in the energy conversion processes in the two types of fires, there is an enormous differenc in rate of energy yield. For example, there were periods in th Buckhead fire in north Florida in March 1956 when the rate c spread probably exceeded 8,000 acres per hour. The rate of energ release from this fire would compare favorably with the rate c energy release from a summer thunderstorm.

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[4]Although a detailed discussion is outside the scope of this paper, energ conversion processes in a fire can be studied by a thermodynamic procedu in which a large fire, like a thunderstorm, can be treated as a heat engin The efficiency of a heat engine is measured by the fraction of heat or therm energy that can be converted into the kinetic energy of motion. A 2-dime sional fire has an efficiency as a heat engine that is very nearly zero or, at t most, only a few hundredths of one percent. A major high-intensity fire h an efficiency as a heat engine that may reach 5 percent or more.

Summary

Combustion is basically a chemical chain reaction that can be divided into three separate phases: (1) Preheating and distillation, (2) distillation and the burning of volatile fractions, and (3) the burning of the residual charcoal.

For a forest fuel, ignition is the link between phase 1 and phase 2 of the combustion process.

For most forest fuels the heat of combustion is between 8,000 and 9,000 B.t.u.'s per pound on a dry weight basis.

Heat is transferred by conduction, convection, and radiation. A fourth means of heat transfer might be defined as mass transport and is the familiar phenomenon of spotting, which becomes increasingly important on high-intensity fires.

Fuel moisture has more effect on the ignition and combustion process than any other factor.

Low-intensity fires are essentially 2-dimensional phenomena, and major high-intensity fires 3-dimensional. The third dimension of a high-intensity fire permits the conversion of part of its heat energy into the kinetic energy of motion, which changes the relative significance of the various combustion factors and greatly modifies their expected effects. For this reason a high-intensity fire cannot be regarded as a magnified version of a low-intensity fire.

The relation of fire behavior to the combustion process can be understood by the use of a group of basic fuel factors which are (1) combustion period, (2) critical burn-out time, (3) available fuel energy, (4) total fuel energy, and (5) quantity of material available for spotting. Such a group of factors might be used to classify fuels in terms of expected fire behavior.

If atmospheric conditions are such that one or more strong convection columns can form, the following appear to be the main combustion factors that determine the intensity and rate of spread of a major fire:

1. The quantity of available fuel energy, or available fuel, per acre. The magnitude of this quantity depends on a reinforcing relationship between the basic fuel factors. In turn, this relationship is regulated primarily by fuel size and arrangement, fuel moisture, and the intensity of the fire itself.

2. Quantity of firebrand material per acre available for spotting.

3. Probability of ignition from firebrands dropping ahead of the main burning area. This probability depends on several factors, the most important of which is the prevailing relative humidity determining the surface fuel moisture.

A FUEL-MOISTURE STICK WICKET OF NEW DESIGN FOR USE AT OPEN-TYPE FIRE DANGER STATIONS

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Better equipment design is one way to improve the accuracy of records taken at the hundreds of open-type fire danger stations now in operation in the East and South.

In this connection, the fuel-moisture stick wicket illustrated in figure 1 offers several improvements over the one described in Technical Note 71.[1] These improvements are: (a) the upper projections of the frame support the layers of screen at a uniform 4 inches above the sticks; (b) the lower cross members of the

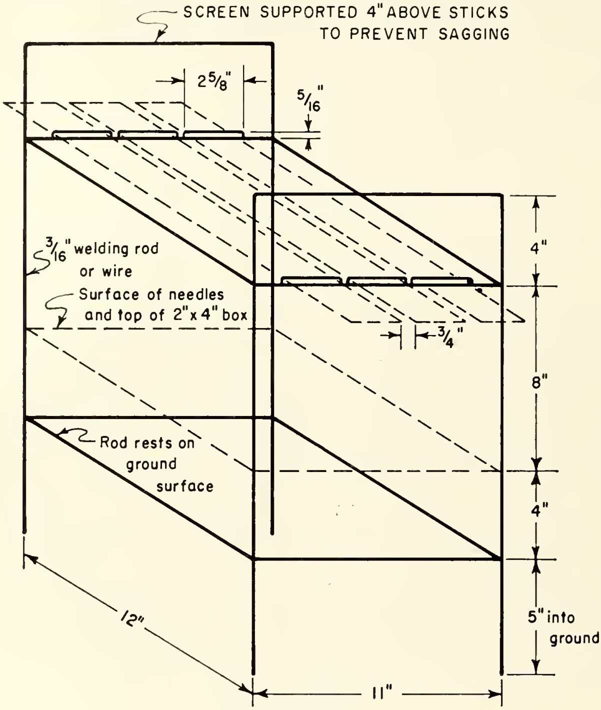

FIGURE 1.

frame rest on the surface of the ground, minimizing penetration, and support the sticks at a uniform 8 inches above the litter and 12 inches above the ground; and (c) the individual slots at each end of the wicket provide positive positioning of the sticks with respect to the screens, litter, and each other.

The Southeastern Forest Experiment Station recommends that the new wicket be used as new danger stations are installed or old stations rebuilt.

[1] Lindenmuth, A. W., Jr., and Keetch, J. J. Open method for measuring fire danger in hardwood forests. U. S. Forest Serv., Southeastern Forest Expt. Sta. Tech. Note 71. March 1949.

FIRE PREVENTION EXHIBIT BY THE SHAWNEE

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District Ranger, Shawnee National Forest

Many opportunities to present fire prevention exhibits at fairs and other celebrations are passed up because of the extra work and expense. But at approximately 4-year intervals, we are able to find the time and money to plan and set up an exhibit. To lessen the work entailed in such planning, a description of an exhibit held at the Jonesboro Lincoln-Douglas Homecoming Festival, August 8-11, 1956, may prove helpful.

Fire prevention was the main objective, but prevention cannot be separated from management of forest resources, especially timber and water. An attempt was made to show the economic importance of these resources to southern Illinois and to point out the value of protection to the lumber industry.

The festival was held outdoors; therefore, the kind of material that could be used was limited. Two tents, 14 by 16 feet and 14 by 14 feet, were borrowed from the Nicolet National Forest in Wisconsin. A Smokey Bear costume and photographs for a tree identification quiz were obtained from the Forest Service Regional Office in Milwaukee. Boy Scout Troop 44 of Anna, Ill., accepted duty at the exhibit as participation in a conservation project. In teams of two the Scouts explained the exhibits and contests and guarded the display both day and night.

Believing that people like both to compete and win, we worked up four simple contests and a volume-guessing contest. These games were "bait" to get people thinking about timber and fire. For the winning contestants, local merchants contributed 16 prizes, such as a double-bitted ax, an electric clock, and a card for 12 grease jobs.

More than 90 feet of space along the midway of the festival was used. At the left end of our space a jeep-tanker and tractor-plow unit were parked. Next to the plow unit, but out in front, was the flag on a 15-foot staff. Next, we erected the 14- by 16-foot tent containing: (1) a small 3-foot table with quiz sheets; (2) two wood sections for the age-of-tree contest, one 51 years old from a managed forest and the other 102 years old from an unmanaged forest (people registered and guessed the difference in age of the two sections); (3) a 4-foot showcase containing prizes to be awarded the contest winners; (4) pictures on a 4- by 8-foot panel for the tree identification contest. Outside this tent the nail-driving contest for ladies took place. Each contestant registered and recorded the number of blows necessary to drive a nail into a wood block.

In the second tent we displayed on one side a 4- by 8-foot panel of forester's tools with 3- by 5-inch signs for each tool and on the opposite side a similar panel of fire-fighter's tools. Between the panels a 30- by 70-inch table held a picture panel and sample

bulletins. Postal cards were available for ordering bulletins, but no material was handed out. In front and to the right of this tent a tripod held a panel on which hung 2- by 3-foot fire prevention posters. Between the two tents, but out in front, was a forest entrance portal sign.

Next, we decked 16-foot pine logs, cut from an 18-year-old plantation and selected for uniform size of 12-inch butts, to be used in a chopping contest. The chopping contest with seven participants was held on Friday night in the area next to the log deck (fig. 1).

So that visitors might know there was to be such a contest, a sign on a post indicated where and when it would be held and how to register for it. Through a portable public address system the chopping was described; the growing of trees as a crop and how protection contributes to rapid growth was also explained.

To the right of the chopping area was stacked a deck of common native hardwood logs. Visitors seemed interested in the kinds of wood grown in the area and in the marked differences between the species.

At the end of our area we parked a log truck loaded with mixed logs. Contestants registered and guessed the volume in board-feet. Here, too, a sign announced the volume-guessing con-

FIGURE 1.—Chopping contestant attracts interest. Sign holds announceme and lists rules.

test and stated that 19 similar loads were hauled each workday from national-forest land on the Jonesboro District in 1955.

On Saturday night a tie-hewing demonstration was given. Two men each made a tie. Again the public address system was used to describe the life of a tie-hack and to tell something of the history of logging in southern Illinois and the progress made since tie-hacking days.

Hand-printed signs described each display. Such signs also stated the rules of each contest. Smokey Bear appeared every evening, strolled through the crowd, shook hands with the children (fig. 2), greeted parents with remarks on forest management, or drove the tractor forward and back in front of the tents. On Wednesday, Smokey rode the jeep in the parade. Smokey always attracted a crowd. (Construction hint—costume should be air-conditioned.)

FIGURE 2.—Smokey does his part.

There was good press coverage during the festival. Pictures of Smokey and of the chopping contestants appeared in the local papers. The entire layout cost approximately $300 in materials, freight, and time of regular personnel. It was well worth the cost. Everybody had fun, and young and old were educated in fire prevention.

SIMPLIFIED METHOD OF TEACHING USE OF COMPASS

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Teaching the use of the Forest Service compass to a group of prospective smokechasers and lookouts is often a tedious and time-consuming job. The students are invariably confused by the fact that the azimuth circle is reversed on the compass, and the "E" and "W" are interchanged. It is difficult to put across the idea that the needle is actually a stationary point of reference

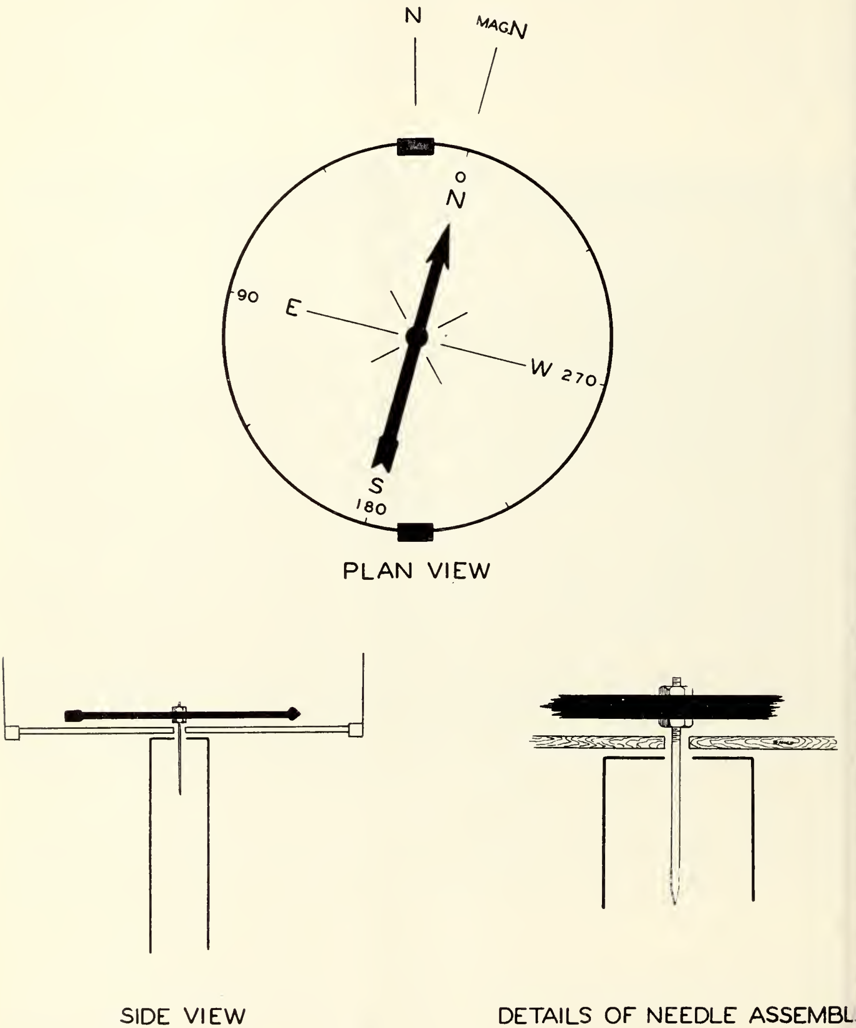

Figure 1.—The "compass" showing alidade positioned for an east declinatio and details of the needle assesmbly.

when allowed to come to rest, and that its purpose is to show the direction in which the alidade is pointed.

A device found effective in demonstrating the principle of the compass and valuable for group instruction was built by the writer while an assistant ranger on the Kaniksu National Forest. It can be constructed by making a circular dial from a piece of plywood approximately 2 feet in diameter with the azimuth circle printed around the edge in a counterclockwise direction (fig. 1). The size of the dial is not important, but it should be large enough for visibility in group participation. Place alidade bars at the north and south points with the hair to the north as usual and with correction for declination. The alidade can be homemade or salvaged from an old-style bar alidade.

Bore a $\frac{3}{8}$-inch hole in the center of the plywood board and mount the board on top of a short post by means of a $\frac{1}{4}$-inch iron pin through the hole and into the top of the post. The board should be free to rotate. Rigidly attach a compass "needle" of wood construction on top of the pin by means of two nuts, and orient it toward magnetic north. *The needle must be stationary* and the board allowed to rotate under it.

Now, as the "compass" is turned in any direction, the north end of the needle will point to the azimuth reading appropriate to the direction of the alidade. With this model compass it is simple to explain that the needle is always stationary and merely provides the reading for the alidade. It becomes obvious to the students why the azimuth dial must be reversed because as the compass is turned to the west, for example, the needle, although stationary, appears to move to the east.

This model also makes the significance of the magnetic declination easily understood. When the compass is turned to a position where the needle points to zero, the alidade is oriented to true north.

THREE BIG E'S IN FIRE PREVENTION

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In 1955, incendiarism was responsible for more fires in the United States than any other cause (29.4 percent). Next in number of fires were debris burning (23.2 percent) and smokers (18.1 percent). Sixty-five percent of all fires occurred in the 11 States of the South. In fact, 88.2 percent of all incendiary fires were in the South. To narrow the field further, 6 States—South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana—accounted for 76.3 percent of the Nation's incendiary fires. Analysis of county records shows that in these States the principal incendiary area is in the Coastal Plain counties. In South Carolina, for example, the 21 Coastal Plain counties accounted for 86.4 percent of the 2,600 incendiary fires in the State's 46 counties during fiscal year 1955.

Incendiarism is, therefore, a special fire problem in the six Coastal Plain States. This area, important to the growing of longleaf, slash, and loblolly pines, is one in which prescribed burning is being or can be used for silvicultural purposes, disease control, and fuel reduction.

Although incendiarism is the No. 1 cause, fire prevention educational campaigns have scarcely mentioned the word "incendiary." By poster, platter, pamphlet, and other means the educational efforts have been directed against the second and third causes, debris burning and smoking. The principal lines of appeal have been (1) to urge the exercise of care and (2) to convey an appreciation of the values destroyed or damaged by fires. Both of these appeals are good, but they do little toward fostering an anti-incendiary attitude of the general public who do not set fires. Many people are amazed to learn that any fires are set intentionally. There are those who believe that the answer to incendiarism is law enforcement. The thought is often expressed that althoug education can reach children and reasonable-minded adults, th incorrigible woods burners must be restrained.

When law enforcement is directed against incendiarism, i encounters problems peculiar to incendiarism as a crime. Usuall there is no eye witness to the act and little or no evidence is lef for laboratory analysis. Often the best that can be done is a cir cumstantial case indicating but not proving guilt. Even witnesse to circumstantial evidence are not easily found because they ar reluctant to testify. In the incendiary belt, setting fire to othe people's woods is not regarded as a crime. Testifying against one' neighbor on such a matter is an unfriendly act. In the face of suc an attitude, law enforcement can hardly succeed. The effort t create an anti-incendiary attitude on the part of most of th people and thereby put them on the side of law enforcement ha not profited much by the educational campaigns.

Some people think of education and law enforcement as alternative courses, either one of which may be followed. Education and enforcement are not alternatives; they are partners. Prevention of incendiary fires might well borrow the three E's of traffic safety—Education, Enforcement, and Engineering. Each of these is a part of the program which needs all three to succeed.

In following the idea of a program similar to that for highway safety under the three E's, let us consider Enforcement first. Just as the States have adopted adequate highway safety laws, so the States must have adequate forest fire laws. A necessary step would be to class incendiarism as a felony tried in the superior courts, rather than a misdemeanor tried by magistrates. Also, just as the States have created highway patrol forces, they should appoint officers to enforce the fire laws. All fire-control organizations find it manifestly impossible for the same personnel to handle suppression of large numbers of incendiary fires and also to consistently accomplish investigation. The job is even more impossible for those who, in addition, are responsible for heavy programs of resource management.

Fire law enforcement officers should have no responsibility for fire suppression action. The number of officers might be relatively small but provision should be made for their reenforcement during "rush seasons." Assistance in investigations, patrolling special areas, and surveillance of suspects might be given by sheriff's deputies, county police, game wardens, and highway patrolmen.

When not engaged in investigation, fire law enforcement officers should spend most of their time on Education. They must instill in the general non-fire-setting public the idea that setting fire to other people's woodlands is a crime. Then, they must go further and help create a militant anti-incendiary attitude that will lead to aggressive cooperation by the public. Obviously, the educational work necessary to swing neighbors into giving evidence in incendiary cases would have to be directed against incendiarism, not against other causes.

Law enforcement officers should work with individuals and groups. Ready to be used is a vast field of educational material. Also available are the innumerable devices that the educational and advertising experts could create if their talents were directed against incendiarism.

To Education and Enforcement must be added Engineering. There are measures that are neither education nor enforcement but which might be used to combat incendiarism. These measures are mostly physical actions and may well be grouped under engineering. In a recent letter to *American Forests*, Professor H. H. Chapman reminds readers that prescribed burning could play a definite part against incendiarism. There are three principal ways in which prescribed burning could be used.

1. The cause or reason for incendiarism can often be removed by prescribed burning. Be it cattle grazing, turkey hunting, or tick

eradication, the need can probably be served better by a prescribed burn in January than by a wildfire in March. Under some circumstances post-logging slash burning is possible and preferable to the risk of wildfire. Fuel reduction burns in some areas might be increased to once every 3 years.

2. The incendiarists can be denied easy access to roadsides by burning wide firebreaks on both sides of roads. At least, the incendiarists could not flip burning matches from moving cars into the woods. They would be compelled to stop, get out, and cross the burned strip twice—all of which increases their chances of detection and apprehension.

3. An intensive effort should be directed toward breaking up large areas into better patterns of prescribe-burn blocks. The improved layout would make it more difficult for incendiarists to burn large areas in one attempt. The incendiarist who wants a large area burned—for any reason—might be forced to set a dozen fires to do so, each time increasing his chances of being apprehended.

To summarize, it is evident that the prevention of incendiary fires is a matter of changing people's attitudes. The effort to do so may be called Education, but it must be directed against incendiarism, not to other things. Education must be backed by Enforcement, because there *are* incorrigible woods burners. The enforcement officers should also work at education. The success of their enforcement work is directly affected by the success of their educational work. The physical conditions that allow incendiarism to thrive can be greatly improved by prescribed burning, which is here called Engineering. The three measures—Education, Enforcement, and Engineering—might do as much for prevention of incendiary fires as they have done for highway safety.

USE AND EFFECTS OF FIRE IN SOUTHERN FORESTS: ABSTRACTS OF PUBLICATIONS BY THE SOUTHERN AND SOUTHEASTERN FOREST EXPERIMENT STATIONS, 1921-55

David Bruce and Ralph M. Nelson
Southern and Southeastern Forest Experiment Stations

Recent catastrophic forest fires in the South have intensified interest in the damages wrought by fire, and in the possibility of using fire to reduce hazardous accumulations of fuel. The expanded fire prevention campaign that was begun following the Southern Forest Fire Prevention Conference in April 1956 has stimulated a demand for information about fire effects. The steady progress of southern forest management has brought new calls for facts about the silvicultural uses of fire, and about the effects of burning on forest watersheds, game habitat, and forage.

Since their establishment in 1921 the Southern and Southeastern Forest Experiment Stations have issued many publications on these subjects. A great deal of this material is now out of print and accessible only in large libraries. These abstracts should make possible a ready review of the publications of the two Stations, and should guide the selection of references for further reading.

It should be noted that the abstracts do not deal with fire behavior or control. Nor do they include publications by agencies other than the Southern and the Southeastern Forest Experiment Stations. Many of the unreviewed items can be located through the literature cited in K. H. Garren's "Effects of fire on vegetation of the southeastern United States," Bot. Rev. 9: 617-654. Others may be found in some of the publications abstracted herein—specifically the lists of references compiled by Miss Helen Boyd and the bibliography in W. G. Wahlenberg's *Longleaf Pine*.

Abell, M. S.
1932. Much heartrot enters white oaks through fire wounds. U. S. Forest Serv. Forest Worker 8 (6) : 10.

Heartrot caused 40 percent cull of mature white oaks cut in 1930 in Virginia. Rot was traced directly to fire scars in one-third of the trees, and fire probably caused rot in most of the badly rotted and hollow trees. Scars indicated 30 different fires 40 to 236 years before cutting.

Arend, J. L.
1941. Infiltration as affected by the forest floor. Soil Sci. Soc. Amer. Proc. 6: 430-435, illus.

A study in the Missouri Ozarks on seven soil types showed that infiltration was 38 percent lower in adequately stocked oak-hickory stands burned annually than in similar stands protected against fire and grazing for 5 or 6 years. Infiltration was 59 percent lower on heavily grazed unimproved pasture than on protected woods soils, and 33 percent lower on pasture than on annually burned woods soils. Removal of L + F layers did not reduce infiltration so much as annual burning.

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1948. Influences on redcedar distribution in the Ozarks. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 58. [Processed.]
See item immediately below.

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1950. Influence of fire and soil on distribution of eastern redcedar in the Ozarks. Jour. Forestry 48: 129-130.
Redcedar has thin bark and is easily killed by surface fires except on rough stony land where vegetation is too sparse to burn readily. With fire protection, redcedar may become plentiful on better sites.

Barrett, L. I., and Downs, A. A.
1943. Hardwood invasion in pine forests of the Piedmont Plateau. Jour. Agr. Res. 67: 111-128, illus.
In burned shortleaf pine stands, understory climax hardwoods were present in half the amounts found in unburned stands. Understory pine reproduction in burned shortleaf stands increased markedly with advancing age of overstory. Unburned stands showed an opposite trend.

——— Jemison, G. M., and Keetch, J. J.
1941. A method for appraising forest fire damage in southern Appalachian mountain types. Fire Control Notes 5 (2): 101-105. *Also in* U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 44, 13 pp. [Processed.]
The study was based on 150 random ¼-acre plots on 41 burns and 4 large, permanent, burned-over experimental plots in the southern Appalachians. Elements of fire damage considered were: (1) immediate losses resulting from the fire-killing of trees of sawlog size, (2) delayed losses resulting from cull, (3) lowered future sawtimber volumes caused by the killing of trees under saw-log size, (4) reduced growth rate of some surviving trees. A table gives average damage per acre in dollars by fire severity, condition class, forest type, and degree of stocking.

Bickford, C. A.
1942. Cost of controlled burning. Jour. Forestry 40: 973.
The cost of burning depends on the purpose and the care needed to do the job on any particular area.

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1942. The use of fire in the flatwoods of the Southeast. Jour Forestry 40: 132-133.
Mentions five uses of fire in the Southeast: silviculture, protection, gam management, grazing management, and pest control. Discusses protectiv burning by (1) fuel reduction, and (2) creation of barriers. Suggests analysi of benefits, costs, and damage, and application of all available knowledge t get good results.

——— and Bruce, D.
1948. Fire and longleaf pine reproduction. South. Lumberma 177 (2225): 133-135, illus.
See Bruce, D., and Bickford, C. A., 1950.

——— and Bull, H.
1935. A destructive forest fire and some of its implication U. S. Forest Serv. South. Forest Expt. Sta. Occas. Pape 46, 4 pp. [Processed.]
Sixty acres of Elk Pasture, near Urania, La., burned on September 1 1932. Fire had been excluded for 19 years. There were 11 old-growth se trees and dense stands (900 per acre) of 19-year-old pines—either loblol

1-10 inches in d. b. h. and 15-50 feet tall or longleaf 1-6 inches in d. b. h. and 10-40 feet tall. Pine needle litter lay 3 inches deep and was also draped on branches and brush. Fire killed all saplings and 96 percent of the seed trees. It is suggested that periodic controlled burning in the longleaf pine type is a more logical practice than either fire exclusion or complete absence of fire protection.

——— and Curry, J. R.
1943. The use of fire in the protection of longleaf and slash pine forests. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 105, 22 pp., illus. [Processed.]
Considers in detail obstacles and benefits of fire use in the Southeast and the steps to be taken: analysis, area selection, examination, mapping, detailed plans, execution, and critical review of results.

——— and Newcomb, L. S.
1947. Prescribed burning in the Florida flatwoods. Fire Control Notes 8 (1) : 17-23, illus.
In the flatwoods, dense slash pine sapling stands unburned for 10 or more years are subject to severe damage from wildfire. Such damage can be avoided by prescribed burning. Steps in executing a prescribed burn are analysis, planning, preparation, burning, and appraisal. Discusses stand size, weather, and execution of burning.

Biswell, H. H., and Lemon, P. C.
1943. Effect of fire upon seed-stalk production of range grasses. Jour. Forestry 41 : 844.
Burning greatly increases seedstalk production of native species, especially pineland threeawn and Curtiss dropseed.

——— Foster, J. E., and Southwell, B. L.
1944. Grazing in cutover pine forests of the Southeast. Jour. Forestry 42: 195-198.
From studies near Plymouth, N. C., the authors conclude that there is no place for prescribed burning in the reed forage type. Fires delay the grazing season about 2 weeks, reduce the carrying capacity the following year, and make the reeds more liable to be killed by grazing.

——— Southwell, B. L., Stevenson, J. W., and Shepherd, W. O.
1942. Forest grazing and beef cattle production in the Coastal Plain of Georgia. Georgia Coastal Plain Expt. Sta. Cir. 8, 25 pp., illus.
A survey of 106 cattle-producing farms in 1941 revealed that about 40 percent practiced prescribed burning to insure against devastating fires, to check brush invasion, and to improve grazing. Many attempted to protect reproduction areas and then to burn portions of their forest land every 2 or 3 years.

Boyd, H.
1952. Burning for control of brush and brown spot disease: selected references. U. S. Dept. Agr. Library and South. Forest Expt. Sta., 4 pp. [Processed.]
A list of 44 references dealing with the South.

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1952. Studies of fire damage in hardwood timber: selected references. U. S. Dept. Agr. Library and South. Forest Expt. Sta., 4 pp. [Processed.]
A partly annotated list of 32 references.

Brender, E. V., and Nelson, T. C.
1954. Behavior and control of understory hardwoods after clear cutting a piedmont pine stand. U. S. Forest Serv. Southeast. Forest Expt. Sta., Sta. Paper 44, 17 pp., illus. [Processed.]

Control by cutting lasted little over a year; burning effects lasted 2 years.

Brinkman, K. A., and Swarthout, P. A.
1942. Natural reproduction of pines in east-central Alabama. Ala. Agr. Expt. Sta. Cir. 86, 12 pp., illus.

A survey of pine reproduction in 4 counties indicated that frequent fires had prevented establishment of pine reproduction on about 40 percent of the area. Fire exclusion for 5 years after seedfall appeared necessary to assure adequate reproduction. See Wakeley, P. C., 1944.

Bruce, D.
1947. Thirty-two years of annual burning in longleaf pine. Jour. Forestry 45: 809-814, illus.

The Roberts plots at Urania, La., have demonstrated that longleaf seedlings must be protected from free-ranging woods hogs, and that, under fence, longleaf seedlings on good sites can survive annual winter fires and grow past the size at which they are retarded by such fires. The Roberts plots also show that where fire is excluded and there are loblolly or shortleaf seed trees nearby, these species will invade, and even small numbers of them in dense young longleaf stands of the same age will dominate the area. See Wyman, L., 1922.

———
1949. Longleaf regeneration improved by burning. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 60. [Processed.]

Fire before seedfall improves seed catch, survival, and growth of longleaf. See Bruce and Bickford, 1950, for a complete report on the study.

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1949. Seed loss to birds unimportant on fresh burns. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 63. [Processed.] *Also in* Naval Stores Rev. 59 (30) : 5 *and* South. Lumberman 179 (2249) : 221.

In south Mississippi in 1947 and 1948, birds ate very little of the longleaf seed on several small fresh burns having heavy seed supplies.

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1950. It isn't the ashes. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 66. [Processed.] *Also in* Naval Stores Rev. 60 (2) : 4.

Rapid early growth of longleaf seedlings on spots where pine logs have recently burned seems due to the fact that fire killed the grass roots rather than to any fertilizing or mulching effect of the wood ashes.

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1951. Factors affecting fuel weight. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 73. [Processed.] *Also in* South. Lumberman 183 (2297) : 206

See Bruce, D., 1951, *Fuel weights on the Osceola National Forest.*

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1951. Fire resistance of longleaf pine seedlings. Jour. Forestry 49: 739-740.

Longleaf seedlings germinating on fresh burns survived fires well when a year old because the roughs were thin; seedlings that had germinated on 1-year and older roughs suffered severe mortality. Size and vigor of seedlings

are important in estimating probable survival. When longleaf seedling stands are large enough to start height growth, fires kill few seedlings that would not have died from other causes in 2 or 3 years.

——— 1951. Fire, site, and longleaf height growth. Jour. Forestry 49: 25-28, illus.

Two similar studies of fire effects on longleaf seedlings in Mississippi and Florida indicated that local differences in soil had more influence on height growth than did fire. In Florida, the unburned seedlings grew best; and the more frequent and more severe the fires, the poorer the survival and growth. On a better site in Mississippi, growth was improved by the use of light fires (both winter and summer) when seedlings were 4 years from seed.

——— 1951. Fuel weights on the Osceola National Forest. Fire Control Notes 12 (3) : 20-23, illus.

Density of stand, age of rough, and understory brush affected fuel weight in north Florida. Dense stands had 4 tons more fuel than open stands. Ten- to 15-year roughs had about 5½ tons more fuel than 1-year roughs. There were about 2 tons more fuel where gallberry or palmetto plants were present than where they were absent. Fuel weights per acre ranged from 1½ tons on open 1-year roughs with no brush to 22 tons under dense stands having 10-year or older roughs with palmetto understory.

——— 1952. Fire pruning of slash pine doesn't pay. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 78. [Processed.] *Also in* Fire Control Notes 13 (2) : 17.

A small gain in pruning 8-year-old slash on an upland site by severe fire was offset by loss of one-half year's growth.

——— 1954. Mortality of longleaf pine seedlings after a winter fire. Jour. Forestry 52: 442-443, illus.

Brown-spot defoliation may be more important than height of longleaf seedlings in determining how many ½- to 4-foot seedlings will be killed by fire. In a light winter fire maximum mortality was in seedlings 1 to 1½ feet tall. All size classes of seedlings over two-thirds defoliated by the brown-spot needle blight a year before the fire suffered more than 38-percent mortality. Brown-spot reduced fire resistance of seedlings ½ to 1½ feet tall more than of seedlings less than ½ foot tall. The best way to insure low mortality is to keep seedlings healthy by burning before many of them are more than one-third defoliated by the disease.

——— 1955. Longleaf led the way. La. State Univ., School of Forestry, Fourth Ann. Forestry Symposium Proc., pp. 79-85. [Processed.]

Frequent fires for thousands of years resulted in almost pure stands of virgin longleaf pine on the Lower Coastal Plain. The sandy, gently rolling soils were not damaged by fire, frequent fires kept the fuel light, and longleaf was the most fire-resistant species present. Since logging of the virgin stands, it has been found that seedbed preparation and brown-spot control are necessary to get second-growth longleaf stands. Use of fire is the most economical means of accomplishing these purposes, and also will result in lower fuel hazard, reduced competition, and improved spring cattle grazing. Primary purposes for use of fire in other southern pine types are for understory shrub-hardwood control and seedbed preparation. Outside of the longleaf type, soils are more susceptible to erosion when the vegetation is burned off, and the more hilly country (as well as the less uniform fuels) makes prescribed fires harder to control.

——— and Bickford, C. A.

1950. Use of fire in natural regeneration of longleaf pine. Jour. Forestry 48: 114-117, illus.

A test begun in 1933 on a 1,000-acre fenced tract in central Louisiana showed that prescribed use of fire improves seed catch, increases survival, and stimulates height growth of longleaf pine. Survival in a dry first year was 22 percent on fresh burns and 1-year roughs and only 10 percent on 2-year and older roughs. More of the yearling seedlings survived the next 6 years on these fresh burns and 1-year roughs, and the survivors made better height growth. Prescribed burning once or twice in the 6-year period after seedlings were a year old resulted in better survival and growth than no burning or annual burning. See Bickford, C. A., and Bruce, D., 1948; Bruce, D., 1949, *Longleaf Regeneration Improved by Burning.*

Byram, G. M.

1948. Vegetation temperature and fire damage in the southern pines. Fire Control Notes 9 (4) : 34-36, illus.

Theoretical curves show the relative fire intensities that longleaf, slash, and loblolly pine should tolerate at different temperatures. At a temperature just above freezing these pines should tolerate a fire more than twice as intense as they would on a warm day when the vegetation temperature is 95°.

——— and Nelson, R. M.

1952. Lethal temperatures and fire injury. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 1, 2 pp., illus. [Processed.] *Also in* Naval Stores Rev. 62 (20) : 18.

The lethal effects of a fire of given intensity vary inversely as the difference between the lethal temperature and initial vegetation temperature. For equal intensities a backfire would scorch a tree crown higher than a headfire. But headfires actually scorch to considerably greater heights because their intensity is almost always several times as great as that of a backfire.

Campbell, R. S.

1954. Fire in relation to forest grazing. Unasylva 8 (4) : 154-158, illus.

Cites use of fire in forest land management in southeastern United States as an example of relation between fire use and grazing. Points out that grazing may reduce fire hazard by removing as much as 44 percent of the herbage and by compacting fuel, and that cattle may make seedbed and fertilized firebreaks relatively fireproof by close grazing. See Campbell and Cassady, 1951 Harper, 1944; Heyward and Barnette, 1934; Heyward and Tissot, 1936; Wahlenberg, Greene, and Reed, 1939.

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1955. Vegetational changes and management in the cutover longleaf pine-slash pine area of the Gulf Coast. Ecol 36: 29-34, illus.

Secondary plant succession in the longleaf-slash pine belt of the Gulf Coastal Plain is influenced by timber cutting, burning, and grazing. The damaging effects of uncontrolled annual burning are in part alleviated by substituting prescribed burning in managed stands, which is useful in reproducing and growing longleaf and slash pines and in improving grazing. Hogs and sheep are serious threats to the early survival and growth of the pines, but cattle usually do little harm. The scrubby hardwoods and underbrush that naturally develop under selective cutting of the pine or under protection from fire are a serious problem. Increasing intensity of land management for timber growing and range grazing may cause deterioration of soil fertility and physical condition.

——— and Cassady, J. T.

1951. Grazing values for cattle on pine forest ranges in Louisiana. La. Agr. Expt. Sta. Bul. 452, 31 pp., illus.

Nutritive value was not greatly affected by burning, but fire removed the rough of grass and weeds and made the fresh forage more easily availabl

for grazing. Prescribed burning should be done only under supervision and advice of a forester, and only when and where the timber stand will benefit.

——— Epps, E. A., Jr., Moreland, C. C., Farr, J. L., and Bonner, F.
1954. Nutritive values of native plants on forest range in central Louisiana. La. Agr. Expt. Sta. Bul. 488, 18 pp., illus.

Burning removes old growth and stimulates succulent new growth high in crude protein and phosphorus. The greatest difference between burned and unburned range was in spring (March-May), when most grasses are in the young-leaf stage. At other seasons, differences were small and inconsistent. In addition to increasing protein and phosphorus, burning makes it possible for the grazing animal to take new growth, unmixed with less nutritious older grass. Repeated burning may reduce amount of forage produced.

Cassady, J. T.
1953. Burning may reduce grass production. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 85. [Processed.]

In central Louisiana, burning for 2 consecutive years reduced grass production during the second year by 42 percent (as compared with an area burned the first year only).

——— Hopkins, W., and Whitaker, L. B.
1955. Cattle grazing damage to pine seedlings. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 141, 14 pp., illus. [Processed.]

Describes eight instances of grazing damage to pine seedlings in central Louisiana. Among other things, points out that fire may lead to heavy damage because cattle tend to concentrate on recent burns.

Chaiken, L. E.
1949. The behavior and control of understory hardwoods in loblolly pine stands. U. S. Forest Serv. Southeast. Forest Expt. Sta. Tech. Note 72, 27 pp., illus. [Processed.]

The use of pre- and post-logging fires for pine regeneration and hardwood control. Discusses season of burning, types and frequency of fires, and cost of prescribed burning.

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1950. This hardwood problem. Forest Farmer 9 (6): 8-9, illus.

The pros and cons of hardwood control by prescribed fire versus other methods.

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1952. Control inferior tree species. South. Lumberman 184 (2306): 38-39. *Also in* The Unit, News Letter 41, pp. 33-36. [South. Pulpwood Conserv. Assoc.]

Points out some of the uses and limitations of prescribed fire to retard the development of competing hardwoods in southern pine stands.

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1952. Annual summer fires kill hardwood root stocks. U. S. Forest Serv. Southeast. Forest Expt. Sta. Research Note 19, 1 p. [Processed.]

Summer fires are more effective than winter fires in killing rootstocks and in reducing size and vigor of sprouts from surviving rootstocks.

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1952. Extent of loss of loblolly pine seed in winter fires. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 21, 2 pp. [Processed.] *Also in* South. Lumberman 185 (2321) : 260.

On areas burned after the bulk of a year's pine seed crop has fallen, seedlings arise either from seed that lodges in sheltered and protected spots or from seed disseminated after a fire. It is unlikely that enough seed will fall during February or March to restock an area adequately.

——— and LeGrande, W. P., Jr.

1949. When to burn for seedbed preparation. Forest Farmer 8 (11) : 4.

If timed to take advantage of heavy seed crops, fire can create a favorable ground surface for loblolly pine seed germination. Peak of loblolly seedfall occurs during the first part of November. The best season to burn therefore is perhaps September or October.

Cooper, R. W.

1951. Release of sand pine seed after a fire. Jour. Forestry 49: 331-332, illus. *Also in* South. Lumber Jour. 55 (8) : 56, 58, 60, illus.

Abundant seedfall, resulting from a wildfire in February on the Ocala National Forest in Florida, gave rise to adequate reproduction. By May, however, the entire crop had been wiped out, presumably by drought and high surface temperatures.

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1952. Regeneration problems in sand pine. South. Lumberman 184 (2303) : 43-44. illus.

Sand pine grows in dense, even-aged, pure stands as a direct result of past fires. Cones are very persistent and seldom open on standing trees. Wild fires open the cones and bring about release of large quantities of seed followed by dense reproduction. However, the old stand having been destroyed, this method has little practical value for the forester.

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1953. Prescribed burning to regenerate sand pine. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 22, 1 p. [Processed.] *Also in* South. Lumberman 186 (2331) : 50.

Early response to prescribed burning indicates that more information is needed on the time of year to burn, on the interval between cutting and burning, and on the number of seed trees.

Craig, R. B., Marburg, T. F., and Hayes, G. L.

1946. Fire losses and justifiable protection costs in the Coastal Plain region of South Carolina. U. S. Forest Serv. Southeast. Forest Expt. Sta., 46 pp. [Processed.]

See item immediately below for type of analysis made in this area.

——— Frank, B., Hayes, G. L., and Jemison, G. M.

1945. Fire losses and justifiable protection costs in southern Piedmont of Virginia. U. S. Forest Serv. Appalachian Forest Expt. Sta., 27 pp., illus. [Processed.]

Analyzes the justifiable expenditure for fire control in seven counties of the southern Piedmont of Virginia by balancing all costs for prevention, presuppression, and suppression against losses to all resource values at stake. Determines the point at which the sum of costs and losses is minimized. The cost of this least-cost-plus-loss point is the economic limit of justifiable expenditure for fire control under existing conditions and present type of fire control.

——— Frank, B., Hayes, G. L., and Marburg, T. F.
1946. Fire losses and justifiable protection costs in the southwestern coal section of Virginia. U. S. Forest Serv. Southeast. Forest Expt. Sta., 45 pp. [Processed.]

Same type of analysis as described in item immediately above.

Davis, V. B.
1955. Don't keep longleaf seed trees too long! U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 98. [Processed.]

Longleaf seed trees not only keep longleaf seedlings small by competition, but their needles increase the amount of fuel. Near seed trees, a fire killed 50 percent of the seedlings 0.2 inch in diameter at the root collar and 10 percent of those that were 0.3 inch. Away from heavy needle fall, mortality in these size classes was 18 percent and 7 percent.

Demmon, E. L.
1926. Fire damage in virgin pine stands of the South. Lumber Trade Jour. 90 (6) : 19-20. *Also in* South. Lumberman 124 (1615) : 47.

In 1924, 24,000,000 acres burned in nine southern States. This was 84 percent of the total in burned area in the United States. Although damage is not confined to mature trees, a large percentage of them bear the scars of repeated fires for over 100 years.

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1928. What the forest fires of 1927 did to the pines on Georgia cutover lands. Naval Stores Rev. 38 (35) : 14-15.

Severe burns in the spring of 1927, when ponds in southern Georgia were dry, killed many trees over 8 inches d. b. h. On two large fires, 32 percent of round longleaf were killed and 56 percent of the turpentined longleaf. Slash pine suffered higher mortality because it grew in previously unburned ponds: 48 percent for round trees, and 78 percent for turpentined. In other areas, slash seedling and sapling mortality averaged 85 percent within 100 yards of ponds and less than 33 percent farther away. Fire resistance increased rapidly with size. Practically all slash less than 7 feet were killed, about 50 percent of the 10-foot saplings, and less than one-third of the 14-foot class. Frequent fires kill young slash before they are fire resistant and keep many areas bare of reproduction.

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1929. Fires and forest growth. Amer. Forests and Forest Life 35: 273-276, illus.

Cites many instances of fire damage to southern forests.

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1931. Fires in the South. U. S. Forest Serv., Serv. Bul. 15 (11) : 2-3.

Cites instances of severe damage from fires in spring of 1927 in south Georgia. Mentions study of fire scars in virgin pine stands.

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1932. Fire in the southern pine forests. U. S. Forest Serv. South. Forest Expt. Sta., 6 pp. [Processed.]

A general resumé of knowledge and opinion regarding the relation of fire to the growing of pine. Points out that each forest stand is different and no general statement will fit all conditions. Fires have been frequent and have caused much damage. Longleaf is the most fire-resistant southern pine. Fire can be used in longleaf stands to prepare seedbeds, control brown spot, and reduce fuel hazard.

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1935. The silvicultural aspects of the forest-fire problem in the longleaf pine region. Jour. Forestry 33: 323-331.

There are more fires in the longleaf belt (50-60 million acres) than elsewhere in the South, and more in the South than elsewhere in the Unitec States, but these fires do not cause as much damage per acre as do fires ir other regions. The frequency of the fires is partly due to the high flammability of the surface vegetation in winter. Controlled burning is used for seed bed preparation, brown-spot control, reducing competition, reducing fir hazard, improving pasture, and bettering habitat conditions for game. To grow longleaf, mastery of fire is essential. Such mastery requires, among other things, more knowledge of fire causes, behavior, effects, and uses.

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1942. Periodicity of forest fires in the South. South. Lumberman 165 (2081): 220-222, illus.

Frequent fires in the South are not so spectacular as fires in other regions but they exact their toll by scarring and killing trees. Fire causes are dis cussed and records of numbers of fire and area burned are presented. Mos fires occur from October through April, with the major peak in March. Onl half of the forest area in the South is now under organized fire protectior

Derr, H. J., and Cossitt, F. M.

1955. Longleaf pine direct seeding. Jour. Forestry 53: 243-246, illus.

Longleaf pine direct seeding should be done in late October or Novembe on light roughs or disked strips. Light roughs are prepared by burning 5 or months before seeding. Fresh burns may attract birds even where the burne area is adjacent to the seeded area. Grass roughs older than one year obstruc germination and may harbor a high rodent population. Disking on poor dr sites may reduce seedling losses if the first summer is dry, and should b done about 3 months before seeding to let the soil settle. Protection agains hogs, grazing animals, birds, ants, and other animals that eat seed or damag young seedlings may be necessary.

——— and Mann, W. F., Jr.

1954. Future forests by direct seeding. Forests and Peopl 4 (4): 22-23, 38-39, illus.

A one-year grass rough is usually the best seedbed for longleaf pine. O dry sandy sites, however, disked strips through a one-year rough ma improve survival.

Eldredge, I. F.

1935. Administrative problems in fire control in the longleaf slash pine region of the South. Jour. Forestry 33: 342-346.

Forest management will remain a gamble until the forest fire problem the South is solved. Although much of the area burned shows little damag there are many areas of vulnerable young slash pine developed by 6 or years of protection in which fire control is extremely difficult in dry year Controlled fire is needed in the reproduction of longleaf pine, and may hav a place in hazard reduction. Advocacy of controlled burning will be very dif cult for public agencies responsible for fire protection.

Elliott, F. A., and Pomeroy, K. B.

1948. Artificial regeneration of loblolly pine on a prescribe burn. Jour. Forestry 46: 296-298.

Effects and costs of a single prescribed fire in loblolly pine in the Coast Plain of Virginia.

Ferguson, E. R.
1955. Fire-scorched trees—will they live or die? La. State Univ., School of Forestry, Fourth Ann. Forestry Symposium Proc., pp. 102-112, illus.

In east Texas in 1954, 975 sample trees, mostly loblolly and shortleaf with some longleaf, were tagged on severe burns. Damage to crowns and trunks was classified soon after the fire, and trees were checked at the end of the growing season to see if they lived or died. Trees most likely to die were those with all foliage consumed; those with all foliage scorched plus very severe bark burn or extensive bark burn; those with both extensive and severe bark burn; and those in summer fires that had either complete foliage scorch, extensive bark burn, or very severe bark burn. Shortleaf pines, suppressed trees, and trees under 10 inches d. b. h. were poorer risks than loblolly or longleaf, trees in upper crown classes, or trees over 10 inches d. b. h.

——— and Stephenson, G. K.
1953. Fire effects studied. South. Lumberman 187 (2345): 244, illus. *Also in* Fire Control Notes 15 (3): 30-32, illus.

In east Texas, fire may be used to kill young hardwoods and to improve seedbeds for pine. Studies are under way to measure effects of these fires on soils and watershed conditions and on hardwoods and pines.

——— and Stephenson, G. K.
1955. Pine regeneration problems in east Texas: A project analysis. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 144, 72 pp., illus. [Processed.]

Reviews literature dealing with prescribed burning for seedbed preparation and for improving seedling survival. Suggests additional work to define the most effective burning conditions, to measure effects of reduced root competition on soil moisture, and to measure possible effects on watershed values.

Forbes, R. D.
1924. Fire in loblolly pine, Urania, Louisiana. U. S. Forest Serv., Serv. Bul. 8 (17): 5-6.

Three sets of plots were established for observing effects of burning on loblolly pine. In a sapling and pole stand, a spring fire in 1923 weakened trees, and bark beetles (*Ips* sp.) attacked them. A summer fire was lighter because the fuel was moist. Fall was too wet for any burning.

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1925. White smoke. Amer. Forests and Forest Life 31: 458-462, illus.

Fire prevention depends on knowledge of fire causes. In the Southeast and possibly in California, a major cause of fire is burning to "improve" grazing conditions. In the Southeast, it seems possible in the future to grow more and better cattle and timber by confining cattle to pastures having about ¼ to ½ the present open range area.

Forsling, C. L.
1936. Forest fires in Central Europe. Farmers' Federation News 16 (7): 18.

Fire causes relatively little damage in the forests of Central Europe as compared to the United States. Europeans have a greater appreciation of the social and economic value of forest land and accordingly are more careful with fire.

Frothingham, E. H.
1931. Timber growing and logging practice in the southern Appalachian region. U. S. Dept. Agr. Tech. Bul. 250, 93 pp., illus.

General information on fire effects in hardwood stands.

Gemmer, E. W., Maki, T. E., and Chapman, R. A.
1940. Ecological aspects of longleaf pine regeneration in south Mississippi. Ecol. 21: 75-86, illus.

Field tests showed that longleaf seed must be protected against birds and mice. Wire tubes, mulches, and drill seeding gave promising results. Greenhouse tests showed best germination on mineral soil and light, well-watered humus. Heavy ash deposits were detrimental. Hardness of surface soil did not affect germination but did affect penetration by radicles. A field trial indicated poorer catch on burned and cultivated seedbeds than on 3-year grass rough because of loss of seed to birds on exposed seedbeds.

Gruschow, G. F.
1952. Effect of winter burning on growth of slash pine in the flatwoods. Jour. Forestry 50: 515-517, illus. *Also in* South. Lumberman 183 (2297): 260, 262, 264, illus. 1951.

Presents some evidence that headfires should not be prescribed where slash pine is a desired stand component and where slash pine reproduction is becoming established. Under favorable conditions, prescribed burning with a backfire results in negligible loss of growth in stands over approximately 12 feet tall. Headfires reduce both height and diameter growth.

Haig, I. T.
1938. Fire in modern forest management. Jour. Forestry 36: 1045-1049.

Discusses the use of fire for numerous management purposes in several regions. Questions whether foresters are taking a sound or desirable position by citing fire as a soil destroyer where only direct action on fertility is concerned.

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1950. Solving the riddle of low grade hardwoods. Amer. Forests 56 (2): 28-30, 40-41, illus.

Under even-aged management, proper use of prescribed fire promises to be one of the cheapest and most effective ways of controlling hardwood invasion.

———
1950. The control of undesirable hardwoods in southern forests. Forest Farmer 9 (11): 9, 11, 14, illus.

General discussion on the use of fire for hardwood control.

Halls, L. K.
1954. Low-cost range improvement pays in the Southeast. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 54, 2 pp. [Processed.]

Spring broadcasting of carpetgrass and lespedeza seed on cutover slash pine forest land, burned the previous fall, increased the annual return from grazing three-fold, from $2.10 to $6.14 per acre.

——— and Suman, R. F.
1954. Improved forage under southern pines. Jour. Forestry 52: 848-851, illus.

Good stands of improved forage species such as Louisiana white clover, carpetgrass, and Dallas grass can be established without tillage in longleaf-slash pine forests following litter removal by burning.

——— Southwell, B. L., and Knox, F. E.
1952. Burning and grazing in coastal plain forests. Ga. Coastal Plain Expt. Sta., Univ. Ga. Bul. 51, 33 pp., illus.

Results of a 7-year study of vegetation and cattle responses to burning frequency (1-, 2-, and 3-year intervals vs. no burning) in longleaf-slash pine

forests of Georgia; ecological trends and chemical composition of forage species, diet and weight gains of young cattle, fuel accumulation, and tree reproduction. General relationship between amount of tree canopy and herbaceous understory is also discussed.

Harper, V. L.
1937. Fire research in the lower South. Fire Control Notes 1 (5) : 229-237.
Tremendous areas are burned by wildfire each year in the South, and at the same time controlled burning is being used in forest management. The acute fire problems appear to be: (1) better fire protection methods; (2) a method of evaluating the effects of fire; and (3) controlled-burning technique.

———
1944. Effects of fire on gum yields of longleaf and slash pines. U. S. Dept. Agr. Cir. 710, 42 pp., illus.
Surface fires that caused no defoliation were followed by slight increases (4 percent) in gum yield in the year following fire but had no effect on second-year yields. Crown defoliation reduced gum yields; the greater the defoliation the greater the loss. Turpentining probably should be deferred at least 1 year after moderate crown damage.

Harrar, E. S.
1954. Defects in hardwood veneer logs: their frequency and importance. U. S. Forest Serv. Southeast. Forest Expt. Sta., Sta. Paper 39, 45 pp., illus. [Processed.]
Briefly mentions decay following fire.

Harrington, T. A., and Stephenson, G. K.
1955. Repeat burns reduce small stems in Texas Big Thicket. Jour. Forestry 53: 847.
In the Big Thicket of southeast Texas, areas were burned once in the spring of 1948, twice in the springs of 1948 and 1951, and three times in the springs of 1948, 1951, and 1952. There was a sparse loblolly-shortleaf pine sawtimber overstory beneath which hardwoods, shrubs, and vines precluded pine regeneration. Burning was done when wind and fuel permitted complete and rapid spread with negligible damage to the overstory. Number of shrubs and hardwoods from ½ to 3½ inches counted in November 1954: unburned, 2,812 per acre; one burn, 1,916; two burns, 1,479; and three burns, 520 per acre. The average reduction of 731 stems for each added fire reflects both kill by reburning and the longer period for reestablishment of small stems since the first and second burns. Repeated burns seem needed to reduce hardwood understories in the Big Thicket type.

Hepting, G. H.
1935. Decay following fire in young Mississippi delta hardwoods. U. S. Dept. Agr. Tech. Bul. 494, 32 pp., illus.
The greatest losses from decay in young Delta hardwoods result from fire-scarring. Decay spreads upward from fire wounds most rapidly in the oaks (2.3 inches per year), and then in ash, sweetgum, hackberry, and persimmon. Relations were established between rate of decay and tree age and diameter, wound size, and fungus causing the decay. Many insects, chiefly ants and termites, inhabited the decayed wood behind fire scars, but there was little insect invasion of sound wood from fire scars.

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1941. Prediction of cull following fire in Appalachian oaks. Jour. Agr. Res. 62: 109-120, illus.
An intensive study of fire-scar butt rot on a large number of commercial logging operations provided a mechanism by which it is possible to predict, for fire scars of different sizes, what the volume of decay will be for any given number of years after a fire. Sixty years after burning, wounds 5 inches wide resulted in only 5 board-feet of cull, while wounds 25 inches wide resulted in 160 board-feet of cull.

——— and Blaisdell, D.

1936. A protective zone in red gum fire scars. Phytopath. 26: 62-67.

Describes a gum-filled zone on the face of red gum fire scars that serves as a protection against decay.

——— and Chapman, A. D.

1938. Losses from heart rot in two shortleaf and loblolly pine stands. Jour. Forestry 36: 1193-1201, illus.

Basal wounds, chiefly those caused by fire, were by far the most common means of entrance for *Polyporus schweinitzii.* Amount of cull from this fungus is reported.

——— and Hedgcock, G. G.

1935. Relation between butt rot and fire in some eastern hardwoods. U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 14, 2 pp. [Processed.]

Results of a study of more than 5,000 eastern hardwoods are presented in a table showing percent of trees by species having fire wounds and the cull percent due to butt rot.

——— and Hedgcock, G. G.

1935. Relation of cull percent to tree diameter and to percentage of trees with basal wounds in some eastern hardwoods. U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 16, 4 pp., illus. [Processed.]

Presents graphs showing the relation of cull percent to tree diameter and percent of trees with basal wounds.

——— and Hedgcock, G. G.

1937. Decay in merchantable oak, yellow poplar, and basswood in the Appalachian region. U. S. Dept. Agr. Tech. Bul. 570, 30 pp., illus.

An analysis of the amount of cull in oaks, yellow-poplar, and basswood throughout the Appalachian region, based on studies from 19 logging operations. Percentages of cull are given for all species by areas, and this cull is related to tree diameter, age, fire, and other factors. Butt rot and top rot are analyzed separately.

——— and Kimmey, J. W.

1949. Heart rot. U. S. Dept. Agr. Yearbook 1949, pp. 462-465.

Many timber stands have been repeatedly burned, so that practically all old trees have scars at their butts. Fungi entering through the scars account for a large proportion of the heart rot in older stands.

Heyward, F. D.

1934. Comments on the effect of fire on feeding roots of pine. Naval Stores Rev. 44 (19) : 4.

The head of the April 13 fire at Cogdell, Ga., killed pine feeding roots to a depth of one inch. Usually damaging heat from surface fire penetrates no more than ¼ inch in dry mineral soils and even less in moist soils. When ponds or swamps dry out, all dry organic matter may be consumed, sometimes to depths of several feet. Both longleaf and slash pine develop new feeding roots in the top few inches of soil soon after fire. Pine roots may be found to be as resistant to fire damage as above-ground portions of the trees.

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1936. Soil changes associated with forest fires in the longleaf pine region of the South. Amer. Soil Survey Assoc. Bul. 17 (Proc. 16th Annual Meeting), pp. 41-42.

Soils protected from fires were more penetrable and porous than soils subjected to frequent fires. Protected sandy soils had a higher hygroscopic

oefficient and higher wilting percent than burned sandy soils, but in sandy oams similar differences were not found. Burned soils had higher loss on gnition, more replaceable calcium, higher pH, and higher total nitrogen than nburned soils. No evidence indicated either severe soil degradation or nprovement from periodic fires. Soil is rarely heated above ignition point f organic matter deeper than ¼ inch. Most differences in soils are attributed to differences in ground cover.

——— 1937. The effect of frequent fires on profile development of longleaf pine forest soils. Jour. Forestry 35: 23-27, illus.

Because of frequent fires, most longleaf pine forest soil resembles a grassand soil more than a typical forest soil. The ground cover is mainly hardy erennial grass and the A_1 horizon is dense and lacks active soil fauna. Where re is excluded, a forest floor 2 to 3½ inches thick is formed, smothering rasses; and soil fauna renders A_1 horizon more penetrable and porous. eavier soils may exhibit crumb structure.

——— 1938. Soil temperatures during forest fires in the longleaf pine region. Jour. Forestry 36: 478-491, illus.

Soil temperatures during fires in natural fuels in longleaf pine forests at epths of ⅛ to ¼ inch generally ranged from 150° to 175° F. for periods of to 4 minutes, with a maximum of 274°. At ½-inch depth the maximum bserved was 195°, but in 15 of 65 records there was no rise in temperature.

——— 1939. Some moisture relationships of soils from burned and unburned longleaf pine forests. Soil Sci. 47: 313-327, illus.

Soil samples from four paired burned and unburned pine stands in northast Florida showed that in about half of 84 determinations at 0- to 2-inch epth, 4- to 6-inch depth, and 8- to 10-inch depth, the unburned soils were ignificantly moister than the burned. None of these paired samples (taken etween July 1936 and July 1937) showed that burned soils were significantly noister than unburned. Differences in moisture retention determined in the aboratory were neither large nor consistent. On areas protected from fire, here was a continuous loose mulch of dead plant material, whereas burned reas had sparser ground cover consisting of young, vigorous plants. Differnces in moisture utilization and mulching effects are probably responsible or the higher observed moisture in unburned soils.

——— 1939. The relation of fire to stand composition of longleaf pine forests. Ecol. 20: 287-304, illus.

In 51 long-unburned forests of longleaf and slash pine from South Caroina to Louisiana, there was a consistently greater number of hardwoods than n nearby frequently burned stands. Where no fires had hindered their growth, ardwoods occupied a considerable part of the dominant crown canopy. When nwanted hardwoods are not over 2 inches in diameter, controlled fires will eep them in check.

——— and Barnette, R. M.

1934. Effect of frequent fires on chemical composition of forest soils in the longleaf pine region. Fla. Agr. Expt. Sta. Bul. 265, 39 pp., illus.

Soils subjected to frequent fires were less acid, and had higher percentages of replaceable calcium and total nitrogen. They also appeared to have nore organic matter, judged by loss on ignition. These differences were bserved in the top 4 to 6 inches of soil. Unburned areas were covered with ine needle litter 2 to 3 inches deep, while frequently burned areas had grass nd weed ground cover. Differences in nitrogen and organic matter are scribed to ground cover, while changes in acidity and calcium are attributed o ash following fire.

——— and Barnette, R. M.

1936. Field characteristics and partial chemical analyses of the humus layer of longleaf pine forest soils. Fla. Agr Expt. Sta. Bul. 302, 27 pp., illus.

Under frequently burned longleaf pine stands, the A_1 horizon, from 2 to 4 inches thick, is more typical of grassland than of forest. The chief source of organic matter is herbaceous roots, mainly grass. With fire protection, an F-layer ½ to ¼ inch thick develops. No continuous H-layer occurs. A period of 8 to 12 years is needed to get a balance between accumulation and decomposition of pine litter. Annual needle fall is from 2,400 to 3,500 pounds per acre. The litter developed under fire protection gives healthy soil condition with rapid decomposition preventing formation of raw humus and soil degradation. The forest floor conserves moisture and prevents soil surface compaction.

——— and Tissot, A. N.

1936. Some changes in the soil fauna associated with forest fires in the longleaf pine region. Ecol. 17: 659-666, illus.

The A_0 horizon of long-unburned longleaf pine forests supported about 5 times as many microfaunal forms as the herbaceous ground cover of frequently burned areas. The top 2 inches of mineral soils of unburned areas contained 11 times more soil microfauna than corresponding soil from burned areas. It is believed the microfauna are responsible for the fact that soils are more penetrable and better aerated on unburned areas than on burned areas.

Hine, W. R. B.

1925. Hogs, fire and disease versus longleaf pine. South. Lumberman 119 (1544) : 45-46, illus.

The Roberts plots at Urania, La., have demonstrated that fencing is necessary to prevent hogs from destroying all longleaf seedlings. Annual fires will eliminate loblolly and shortleaf reproduction but have no serious effect on the number of longleaf seedlings if the first fire comes when seedlings are at least one year old. Brown spot has skilled a few seedlings on the unburned plot. Longleaf on the unburned plot are about 3 times as tall as on the plot burned 10 times, and have 10 times the basal area at breast height. See Bruce, D., 1947; and Wyman, L., 1922.

Hursh, C. R., and Pereira, H. C.

1953. Field moisture balance in the Shimba Hills, Kenya. East African Agr. Jour. 18 (4) : 1-7.

For the equatorial coastal conditions studied, a high tropical forest was considered to be more favorable to ground-water storage than the adjacent annually burned grass vegetation.

Jeffers, D. S., and Korstian, C. F.

1925. On the trail of the vanishing spruce. Sci. Monthly 20: 358-368.

Destructive logging followed by fire threatens to eliminate red spruce in the southern Appalachians. On cutover lands where fire has not burned advance growth present before cutting is developing satisfactorily. But no new seedlings dating from the cutting have appeared. Generally, there is enough advance growth to hold the land for spruce, but not to provide well stocked stands at maturity. Where fire has occurred, the loss of spruce is complete, and in its place are stands of noncommercial fire cherry and yellow birch.

Jemison, G. M.

1943. Effect of single fires on the diameter growth of shortleaf pine in the southern Appalachians. Jour. Forestry 41: 574-576.

A clear distinction is made between the growth of stands and the growth of individual surviving trees after fire injury. Wounding and mortality follow

ng a severe fire may cause a material reduction in stand yields, but individual urviving shortleaf pine trees continue to increase in diameter at a normal ate even though their crowns are entirely scorched by a single fire.

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1944. The effect of basal wounding by forest fires on the diameter growth of some southern Appalachian hardwoods. Duke Univ. School Forestry Bul. 9, 63 pp., illus.

A comprehensive study showing that: (1) basal fire wounding has no sigificant effect on rate of diameter growth or food and water translocation in ellow-poplar and white oak, (2) anatomical changes in phloem and xylem ear fire wounds to quickly circumvent the temporary obstruction are uniersal, (3) slower growth of some wounded scarlet oak trees results from rown injury rather than from physiological or anatomical changes. This lower growth of wounded scarlet oak represents a loss of $0.23 per acre over single rotation in an average stand of second-growth mixed oak in the outhern Appalachians.

Kaufert, F. H.

1933. Fire and decay injury in the southern bottomland hardwoods. Jour. Forestry 31: 64-67.

Fires damage bottomland hardwoods by killing young trees, giving rise to oor-quality sprout stands, and by scarring survivors. It is estimated that re has caused 90 to 95 percent of decay in merchantable stands.

Keetch, J. J.

1944. Sprout development on once-burned and repeatedly-burned areas in the southern Appalachians. U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 59, 3 pp. [Processed.]

On a once-burned area 8 years after burning, dominant sprouts, averaging).4 feet in height, are evident, two-thirds of the ground area is covered, and fine stand is anticipated. By repeated burning, sprouting capacity and rowth rate or vigor are not significantly reduced, but only one-third of the round area is covered and there is evidence of soil deterioration. Sprouting aries by parent tree size and, to some extent, by species.

Korstian, C. F.

1924. Natural regeneration of southern white cedar. Ecol. 5: 188-191, illus.

Discusses the killing effects of fire during dry seasons, the beneficial esults during wetter seasons in regenerating the species, and ecological rends following disastrous fires.

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1927. Timber from southern white cedar pays on coastal swamp land. U. S. Dept. Agr. Yearbook 1927, pp. 617-619, illus.

Strip cutting is preferred to seed trees, with controlled slash fires to rovide a seedbed of exposed surface peat.

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1937. Perpetuation of spruce on cut-over and burned lands in the higher southern Appalachian mountians. Ecol. Monog. 7: 125-167, illus.

Depletion of southern Appalachian spruce forests is due to fire following structive logging. Although the most valuable species in the spruce forest, d spruce does not reproduce effectively under conditions of high altitude and e dry surface layer of moss, peat, and soil, which follows cutting and fire. urthermore, it does not compete vigorously with the associated hardwoods. hus, cutting practices in this type must be directed toward partial or selecve cutting, or even no cutting on those areas reserved for watershed otection.

——— and Brush, W. D.
1931. Southern white cedar. U. S. Dept. Agr. Tech. Bul. 251 76 pp., illus.
Because of thin bark and highly flammable leaves and twigs, southern white cedar is at all ages very susceptible to fire. However, dense stands of reproduction have sprung up on clear-cut areas following single slash fires that occurred when swamps were filled with water and before dormant seeds in the peat had germinated.

Lee, R. E., and Smith, R. H.
1955. The black turpentine beetle, its habits and control. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 138 14 pp., illus. [Processed.]
The black turpentine beetle kills trees in stands that have been disturbed by logging, turpentining, fire, hail, wind, lightning, or other insects. Control by burning stumps is not practical; salvage of dead and dying trees and spraying stumps and seed trees with BHC are recommended.

Lemon, P. C.
1946. Prescribed burning in relation to grazing in the longleaf slash pine type. Jour. Forestry 44: 115-117.
Prescribed burning improves the forage for grazing. Burning can be successfully done if the area selected for burning has an adequate stand of trees is subdivided into small units, if conditions for burning are favorable, and if the job is done by personnel trained in the use of fire.

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1949. Successional responses of herbs in the longleaf-slash pine forest after fire. Ecol. 30: 135-145.
Herbs are classified into three groups, principal, secondary, and "fire followers." Principal herbs are adapted to persist after burning; the less important secondary herbs react to fire roughly in the same way as do the primary; the fire followers quickly invade a burned area but are largely eliminated by 8 or 10 years of protection.

Lentz, G. H.
1931. Forest fires in the Mississippi bottomlands. Jour. Forestry 29: 831-832.
In the spring of 1931 the bottomlands were dry and damaging fires were burning. Decay losses from 1924-25 fires were becoming more evident, and constituted a clear warning that fire protection is necessary if timber is to be grown on the bottomlands.

Lindenmuth, A. W., Jr., and Byram, G. M.
1948. Headfires are cooler near the ground than backfires. Fire Control Notes 9 (4) : 8-9, illus.
In prescribed burning where it is desired to minimize damage to reproduction under 18 inches or so in height, headfires may prove more economic and effective than backfires.

——— Keetch, J. J., and Nelson, R. M.
1951. Forest fire damage appraisal procedures and tables for the Northeast. U. S. Forest Serv. Southeast. Forest Expt. Sta., Sta. Paper 11, 28 pp., illus. [Processed.]
Presents tables for determining average dollar damage per acre according to forest type, stand origin, size class, stand density, season of year, and fire intensity.

Lotti, T.
1955. Summer fires kill understory hardwoods. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 71, 2 pp. [Processed.]
Annual summer fires were more effective than biennial fires.

——— and McCulley, R. D.
1951. Loblolly pine: maintaining this species as a subclimax in the south-eastern United States. Unasylva 5: 107-113, illus.

Summer fires may be needed to kill hardwoods that are too large to be killed by winter fires. At time of regeneration, the pine seedbed can be prepared and the hardwoods checked simultaneously by a pre-seedfall burn. Most favorable season for treatment is September and October.

McCarthy, E. F.
1922. Fire increases dry site type. U. S. Forest Serv., Serv. Bul. 6 (22) : 4-5.

Two fires in the southern Appalachians caused severest damage on dry slopes. Fires favored pines, increased the number of pine seedlings, crippled the mature hardwoods, started disease in the fire scars, and created dense clumps of hardwood sprouts.

———
1928. Analysis of fire damage in southern Appalachian forests. Jour. Forestry 26: 57-68, illus.

Analysis of fire mortality and injury of trees by size. Deductions on the elements of damage and problems awaiting solution are made from the data.

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1933. Yellow poplar characteristics, growth, and management. U. S. Dept. Agr. Tech. Bul. 356, 58 pp., illus.

Instances are cited where dense stands of yellow-poplar seedlings follow light fires that remove the leaf litter. Seedlings and saplings are very susceptible to killing by fire, but when the bark becomes a half inch thick or more, yellow-poplar is one of the most fire resistant of eastern trees. Some information on amount of cull following fire wounding.

——— and Sims, I. H.
1935. The relation between tree size and mortality caused by fire in southern Appalachian hardwoods. Jour. Forestry 33: 155-157, illus.

Presents curves showing the relation between tree size and mortality caused by fires. Suggests a method for rating fire intensity by dividing actual mortality in the 3-inch class into 10 intensity classes and associating mortality in other diameter classes to these as reference points.

McCulley, R. D.
1950. Management of natural slash pine stands in the flatwoods of south Georgia and north Florida. U. S. Dept. Agr. Cir. 845, 57 pp.

Prescribed burning can best be done with a 3- to 10-mile northerly wind from December 15 to February 15. Costs can be reduced by spreading the backfire rapidly so that at least 10 acres will be burned per man-hour. Damage may be reduced by burning only the area absolutely necessary, by avoiding cycle—or quota—burning, and by allowing 10 years of complete protection for development of reproduction. Presents curves of relation of height and diameter growth by crown injury classes.

MacKinney, A. L.
1931. Thirteen annual fires in the longleaf pine type. U. S. Forest Serv., Serv. Bul. 15 (37) : 2-4.

During a 10-year period on an annually burned plot, diameter growth was reduced 9 percent and annual volume growth 22 percent.

———
1931. Longleaf pines subjected to thirteen years' light burning show retarded growth. U. S. Forest Serv. Forest Worker 7: 10-11.

Average d. b. h. of all trees on the annually burned plot was 4.4 inches and on the unburned plot 5.1 inches. Figures are given for difference in increment and in volume of peeled wood.

———
1933. Mortality in longleaf pine pole stand after a hard fire. U. S. Forest Serv., Serv. Bul. 17 (22) : 3.

Table, based on examinations 2 months and 11 months after the fire, shows percentage of trees that died in each of 5 defoliation classes.

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1934. Some effects of three annual fires on growth of longleaf pine. Jour. Forestry 32: 879-881, illus.

On experimental plots burned annually for 3 years mean basal area growth (inside bark) was reduced 42.0± 8.9 percent by burning. Larger trees showed a greater reduction in basal area growth than smaller ones. Reduction in height growth appeared to be negatively correlated with size of tree but was not significant.

———
1934. Some factors affecting the bark thickness of second-growth longleaf pine. Jour. Forestry 32: 470-474, illus.

Analysis of 613 trees from burned areas showed that fire measurably reduced bark thickness.

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1935. Effects of a light fire on loblolly pine reproduction. U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 9, 2 pp. [Processed.]

Table shows cumulative mortality 7, 26, and 50 weeks after a light fire. Mortality of reproduction was very high.

Mann, J. M.
1947. Prescribed burn versus wildfire. Forest Farmer 7 (2) : 4, illus.

How a prescribed burn in a slash pine area reduced a 15-year accumulation of fuel and how a wildfire on a part of the area not prescribe-burned caused severe damage.

Mann, W. F., Jr.
1954. Direct seeding research with longleaf, loblolly, and slash pines. La. State Univ., School of Forestry, Third Ann. Forestry Symposium Proc., pp. 9-18.

Longleaf should be direct-seeded in November after about 2 inches of rain. A one-year rough is the preferred seedbed on most sites. There should be no fresh burns on or near the area because they attract birds. On dry sandy sites, disking may prevent heavy losses if there is a drought in the first summer. Loblolly seeding on sites dominated by poor hardwoods is best done in November on fresh burns. Falling leaves hide the seed from birds. On open land, spring sowing of loblolly is necessary to prevent freezing damage. Disking appears necessary to reduce grass which overtops loblolly seedlings developing on fresh burns and grass roughs. Slash pine may be sowed in fall with no special site preparation.

——— and Derr, H. J.
1954. Direct seeding of southern pines. South. Lumberman 189 (2369) : 115-117, illus.

One-year roughs are usually the best seedbeds for longleaf, although on very dry sites disked strips in one-year roughs may help seedling survival i

a dry summer. Fresh burns on or near the seedbed area are highly attractive to migratory birds. Disked strips in one-year roughs probably are the best seedbeds for slash and loblolly.

——— and Rhame, T.
1955. Prescribe-burning planted slash pine. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 96. [Processed.]
See item immediately below.

——— and Whitaker, L. B.
1955. Effects of prescribe-burning 4-year-old planted slash pine. Fire Control Notes 16 (3) : 3-5.
In central Louisiana, a 600-acre 4-year-old slash plantation with moderate but spotty grazing was prescribe-burned in the winter 1952-53 for hazard reduction without serious damage. All burning was against the wind. Fires killed 8 percent of the trees, mostly those under 3 feet tall. Survivors lost 0.25-foot growth the following year. Generally, slash plantations averaging less than 8 feet tall should not be burned, unless weather and fuel conditions are exactly right and experienced men are on hand to do the burning.

Meginnis, H. G.
1935. Effect of cover on surface run-off and erosion in the loessial uplands of Mississippi. U. S. Dept. Agr. Cir. 347, 16 pp., illus.
Run-off and erosion were measured for 2 years in catchment tanks installed under 8 different cover types, including a mature oak forest unburned for 7 years and a scrub oak woodland subjected to severe cutting, frequent fires, and other abuses. The scrub oak permitted 15 times as much soil loss and 10 times as much direct run-off as the old-growth oak forest, but only 0.3 to 1 percent of the soil loss and 15 percent of the run-off allowed by a barren abandoned field or cultivated land.

Minckler, L. S.
1944. Third-year results of experiments in reforestation of cutover and burned spruce lands in the southern Appalachians. U. S. Forest Serv. Appalachian Forest Expt. Sta. Tech. Note 60, 10 pp., illus. [Processed.]
A combination of burning and grazing followed by planting may be the cheapest and most effective treatment for establishing spruce.

Muntz, H. H.
1947. Prescribed burning of longleaf plantations. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 49. [Processed.] *Also in* Naval Stores Rev. 57 (11) : 5.
See Wakeley, P. C., and Muntz, H. H., 1947.

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1948. Slash pine versus loblolly in central Louisiana. Jour. Forestry 46: 766-767, illus.
Part of a mixed-species planting was burned after 6 years. At 10 years, loss in survival, apparently due to burning, was 20 percent for slash against 34 percent for loblolly; and loss in height was 1 foot for slash and 5 feet for loblolly, indicating that slash pine is more fire resistant under these conditions.

———
1954. How to grow longleaf pine. U. S. Dept. Agr. Farmers' Bul. 2061, 25 pp., illus.
Longleaf is more fire resistant than other southern pines, and may be the only species that will grow successfully where fire protection is inadequate. In longleaf management, fire is used to prepare sites for seeding or

planting, control brown spot, reduce wildfire hazard, and control competin hardwoods. Indiscriminate burning has no place in longleaf managemen Since repeated burning may cause erosion and watershed damage, hilly lan may best be managed for other species. Periodic prescribed burning destroy needles and dead rough, speeding growth of new grass and making it mor available to cattle.

Nelson, R. M.

1935. A method for rating forest fire intensity. U. S. Fores Serv. Appalachian Forest Expt. Sta. Tech. Note 8, 1 p. illus. [Processed.]

Five classes of fire intensity are arbitrarily established, based on percent age of 3-inch trees killed.

——— 1951. More facts are needed on prescribed burning. Fores Farmer 10 (8): 5.

A popular account of the importance of temperature in the use of pre scribed fire, i.e., possibility of obtaining satisfactory results in reducing fuel on cold winter days, hardwood control on hot summer days, and brown-spo control by the use of headfires, which are cooler near the ground than back fires.

——— 1952. Observations on heat tolerance of southern pine needles U. S. Forest Serv. Southeast. Forest Expt. Sta., Sta Paper 14, 6 pp., illus. [Processed.]

Needles of longleaf, slash, loblolly, and pitch pine, when immersed in water bath, had about the same lethal temperatures.

——— and Sims, I. H.

1934. Fire wounds have close relation to exterior discoloratio of bark. U. S. Dept. Agr. Yearbook 1934, pp. 218-220 illus.

See item immediately below.

——— Sims, I. H., and Abell, M. S.

1933. Basal fire wounds on some southern Appalachian hard woods. Jour. Forestry 31: 829-837, illus.

A study of oaks and yellow-poplar wounded by a spring fire in Virgini There was a fairly high correlation between the area of discoloration and th area of wound for all but scarlet oak, which is highly susceptible to wound ing. Of the species studied, yellow-poplar was the most resistant, scarlet oa the least resistant, and black, white, and chestnut oak intermediate.

Osborne, J. G.

1937. Pulpwood and forest fires. Paper industry 19: 661-66

Although most fires may appear to do little damage to southern pin stands, they take an immense toll of seedlings needed for full pulpwood pr duction. Fires in logging slash are particularly damaging; logged area should get extra protection. Loblolly-shortleaf stands need better protectio than longleaf.

——— 1938. Effects of burned faces on later turpentining. Forestr News Digest, Southern ed., May issue, p. 23.

Two years after a severe April 1934 fire in southeast Georgia, turpenti ing was resumed on trees with burned faces. The operator used the minimu jump streak that exposed "sufficient" producing wood. Jump streaks on th windward side were ⅔ inch lower than on other sides, and were ½ inc higher for each additional 4 feet of stem scorched (and averaged 2¼ inches Slash pine showed 6 percent more dry-face than longleaf, leeward faces 1 percent more than windward, and small trees more than large trees.

——— and Harper, V. L.

1937. The effect of seedbed preparation on first-year establishment of longleaf and slash pine. Jour. Forestry 35: 63-68, illus.

Longleaf and slash pine seed were sowed on small screened plots in northern Florida in the winters 1933-34 and 1934-35. One year after seeding, survival counts indicated about twice as many longleaf established on plots burned one year before seeding or disked just before seeding, and 3 to 4 times as many on plots spaded or burned just before seeding, as on plots on 3- or 4-year roughs. Slash plots indicated a similar but less consistent effect of rough. The 1933-34 disked plots had notably high survival, possibly because of moisture retention in the dry 1934 summer. Site preparation does not seem so important for slash, which has frequent and abundant seed crops, as for longleaf, with its infrequent seed years. Burning immediately or one year before longleaf seed fall will improve germination or survival, and either method should give satisfactory reproduction if it successfully combats the bird and rodent problem.

Pessin, L. J.

1939. Effect of the treatment of ground cover on the growth of longleaf pine seedlings. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 25. [Processed.]

Longleaf pine grown in containers for 2 years with grasses were ½ as arge as those with no grass. Burning grass (annually, with seedlings proected against defoliation) resulted in seedlings nearly as large as where here was no grass. See Pessin, 1944, for final report.

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1942. Stimulating the early growth of longleaf pine seedlings. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 44. [Processed.]

See item immediately below.

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1944. Stimulating the early height growth of longleaf pine seedlings. Jour. Forestry 42: 95-98.

Removing grass competition by repeated hoeing greatly stimulated longeaf seedling growth, in comparison to no treatment, or to site preparation y spading, or winter burns for 3 successive years (during burns the seedings were covered with large crocks). Four years after seeding, hoed seedings averaged 26 inches in height and all others 5 inches. (According to the 946 Annual Report of the Southern Forest Experiment Station, after 8 years hese heights were 15 feet and 7.5 feet with no significant differences beween spading, burning, and check.)

——— and Chapman, R. A.

1944. The effect of living grass on the growth of longleaf pine seedlings in pots. Ecol. 25: 85-90.

Longleaf seedlings were grown for 2 years in 1-gallon cans with and vithout grass, and with 250 or 500 ml. of water added per week. Average ry weight was significantly greater with no grass. Without grass, neither nulching nor amount of water affected growth significantly. Average growth f seedlings where *Andropogon scoparius* was burned each winter (with eedling foliage protected) was greater than where grass was clipped twice year, which in turn was greater than where grass was untouched. Similar ifferences did not appear for mixtures of other grasses and forbs for these treatments. Amount of water had a very significant effect on growth of eedlings in competition with *A. scoparius*, but not with other grasses. Weight of grasses produced was not reported.)

Pomeroy, K. B.

1948. Observations on four prescribed fires in the Coastal Plai of Virginia and North Carolina. Fire Control Notes (2 and 3): 13-17.

The effect of fires of different severity on killing of small hardwoods an on fuel consumption.

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1950. Twenty years without fire protection. Forest Farme 10 (3): 12, illus.

A spring wildfire in a cutover loblolly pine stand destroyed all pine repro duction and all hardwoods up to 2 inches in diameter but was followed by bountiful seed crop and well-stocked stands of reproduction. Ten years late a second wildfire again destroyed all reproduction, and two years wer required to produce a seed crop. The delay enabled a vigorous stand of hard wood sprouts to become established; these sprouts are likely to assume dom nance unless treated.

——— and Barron, N. T.

1950. Hardwoods vs. loblolly pines. Jour. Forestry 48: 11 113.

The use of fire, scarification of seed bed, and silvicides in the manageme of loblolly pine.

Putnam, J. A.

1951. Management of bottomland hardwoods. U. S. Fore Serv. South. Forest Expt. Sta. Occas. Paper 116, 60 p [Processed.]

During severe fire seasons, once every 5 or 8 years, fires spread rapidl killing all tree reproduction under 10 years old, and wounding the survivor On bottomland hardwood areas, fire once every 10 years precludes the pra tice of forestry.

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1953. Management possibilities in upland hardwoods, if an La. State Univ., School of Forestry, Second Annual Sym posium Proc., pp. 63-69.

Controlled fire cannot be used in pine-hardwood areas if the hardwoc are to be carried 30 to 40 years. Prevalence of fire on upland pine sites cc tributes to the poor grade of hardwoods found there. Fire exclusion w increase production of good hardwoods.

Roth, E. R., and Sleeth, B.

1939. Butt rot in unburned sprout oak stands. U. S. Dej Agr. Tech. Bul. 684, 43 pp., illus.

Sprout stands that develop after severe burns have less decay than th resulting from cutting operations without fire. Fire preceding the establi ment of a stand kills the cambium and latent buds above the ground line the stumps. Sprout regeneration is thus forced to come from buds at or bel ground level and such sprouts often escape infection from the parent stur

Shepherd, W. O.

1952. Highlights of forest grazing research in the Southea Jour. Forestry 50: 280-283, illus.

Winter burning greatly increased the protein and mineral content native grasses until they reached full leaf stage. Thereafter forage qual on burned and unburned range was fairly similar. Cattle gains were th times higher during the spring. Burning alone had little influence on dens of native forage species but burning combined with heavy grazing reduced density of bunchgrasses and favored the invasion of low-growing spec such as carpetgrass.

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1953. Effects of burning and grazing flatwoods forest ranges. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 30, 2 pp. [Processed.] *Also in* Naval Stores Rev. 63 (12) : 17, 20.

Summary of 7-year study of burning longleaf-slash pine forest range at intervals of 1, 2, and 3 years; ecological trends with and without grazing, chemical composition of forage, diet and weight gains of young cattle, fuel accumulation, tree reproduction. General effect of tree cover on understory vegetation. Based on Halls, Southwell, and Knox, 1952.

——— Dillard, E. U., and Lucas, H. L.
1951. Grazing and fire influences in pond pine forests. N. C. Agr. Expt. Sta. Tech. Bul. 97, 57 pp., illus.

With protection from grazing, burning favored cane in competition with shrubs, but burning increased cane's susceptibility to grazing damage. Fires may be essential for regenerating pond pine stands.

——— Southwell, B. L., and Stevenson, J. W.
1953. Grazing longleaf-slash pine forests. U. S. Dept. Agr. Cir. 928, 31 pp., illus.

From March to September cows spent a high proportion of their time on areas prescribe-burned the previous winter, even though these areas were closely grazed and forage limited. Cattle gains were influenced by amount of burned area available. After September, cattle were more willing to graze unburned areas where forage was more abundant. Grazing capacity during the spring and summer should be based entirely on the burned acreage; at least 6 acres per cow appears to be needed.

Siggers, P. V.
1934. Observations on the influence of fire on the brown-spot needle blight of longleaf pine seedlings. Jour. Forestry 32: 556-562, illus.

A single fire will greatly reduce brown-spot infection in longleaf seedling stands for the first season and often to a lesser extent for the second season. This permits retention of foliage through the second season—a necessity for seedling growth. Before longleaf seedlings emerge from the grass, controlled winter burning at 3-year intervals can be used for disease control.

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1935. Slash-disposal methods in logging shortleaf pine. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 42, 5 pp., illus. [Processed.]

Piling and burning reduces fire hazard immediately, but costs twice as much as lopping and scattering, and creates unfavorable soil conditions under piles. Neither lopping and scattering nor piling have enough advantage over pulling tops to defray the cost. There is little fire hazard after 3½ years, whether slash is treated or left.

———
1944. The brown spot needle blight of pine seedlings. U. S. Dept. Agr. Tech. Bul. 870, 36 pp.

Single fires greatly reduced the disease for the first season and often to a lesser extent for the second. Occasionally, reduction of the disease was still evident after three seasons. A 45-acre fire in a 6-year rough reduced the disease for 1 year but only slightly at the end of 2 years. There was a flight of air-borne spores from dense stands of infected seedlings surrounding the burn 8 weeks after the fire, which may explain the brief sanitary effect. Cattle attracted to the burn by green grass may have helped transfer conidia from infected to healthy needles. Although many fires stimulate growth by reducing the disease for 2 years, even a thousand-acre burn may not be effective if the burn is surrounded by extensive sources of inoculum (such as dense infected seedling stands).

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1945. Controlling the brown spot needle blight of longleaf pine by prescribed burning. AT-FA Jour. 8 (1): 11. *Also in* Naval Stores Rev. 55 (25): 4, 8 *and* Forest Farmer 5 (1): 8.

Brown spot seriously affects longleaf seedling growth when the needle kill on a sample of 100 or more seedlings averages 35 percent. Longleaf seedlings should not be burned until they are in their second season of growth. A good time to burn is in late winter prior to spring growth and again in the third winter thereafter, provided most of the seedlings have become badly reinfected. The duration of disease control by a single fire is affected by the size of area burned, and the presence or absence of nearby dense stands of infected seedlings.

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1949. Fire and the southern fusiform rust. Forest Farmer 8 (5): 16, 21, illus.

Fires in six young slash pine plantations in Louisiana and Mississippi killed branches with fusiform cankers, and thus reduced the number of cankered trees. But there were more new infections on the burned plots than on unburned check plots, possibly because fire induced an earlier break in winter dormancy and provided more tender foliage and shoots when spores were flying. Thus, prescribed burning cannot be recommended to reduce amount of fusiform rust.

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1955. Control of the fusiform rust of southern pines. Jour. Forestry 53: 442-446.

This general discussion of fusiform rust includes the consideration of fire included in the reference immediately above. A single winter fire may kill some cankered branches but if it kills needles but not branches, there will be an unusually early spring increase in new needles and shoots when conditions favor pine infection. The end result of single fires was an increase in number of new cankers.

Sims, I. H.

1932. Establishment and survival of yellow-poplar following a clear cutting in the southern Appalachians. Jour. Forestry 30: 409-414, illus.

Although the first four years following cutting showed an advantage in number of established seedlings of burning over not burning, subsequent competition from ferns and other vegetation nearly eliminated the initial seedling stand.

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1932. Specific differences in basal wounding by fire of southern Appalachian hardwood trees. Abstract in Jour. Elisha Mitchell Sci. Soc. Oct.

An abstract based on a study of 300 mixed hardwood trees following a spring forest fire. The study indicates the relation between external bark discoloration and wound size.

Smith, L. F., Campbell, R. S., and Blount, C. F.

1955. Forage production and utilization in longleaf pine forests of south Mississippi. Jour. Range Mangt. 8: 58-60, illus.

Protein and phosphorous contents of ungrazed grass were only slightly higher on burned than unburned areas. Although these differences were unimportant, cattle preferred to graze on fresh burns, where they utilized from 60 to 90 percent of the forage, as against averages of 13 and 19 percent on unburned range.

Stephenson, G. K.

1955. Better seedling survival is goal of new research. Texas Forest News 34 (3) : 3, 7, illus.

Reports on an excellent stand of first-year seedlings established on a prescribed burn. The stand survived the 1952 drought. The removal of competing trees by cutting, hardwood control, or fire may make more moisture available for seedlings.

——— and Young, D.

1954. 1955 pine cone crop should influence forest management. Texas Forest News 33 (3) :4, 6-7.

Suggests that on selected areas, where competing hardwoods are small and vulnerable, owner may use prescribed fires to prepare stands for reproduction.

Stone, E. L., Jr.

1942. Effect of fire on radial growth of longleaf pine. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 43. [Processed.]

1,200 longleaf pine increment cores from Mississippi and Louisiana were examined. Trees less than 6 inches d. b. h. lost 0 to 65 percent radial growth in the first year after a fire. The average loss was 23 percent. Larger trees lost up to 35 percent, averaging 19 percent. Usually the second year's growth was essentially normal.

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1944. Effect of fire on taper of longleaf pine. Jour. Forestry 42: 607.

Fires causing 50 percent or more defoliation of longleaf pine 5 to 6 inches d. b. h. reduced diameter growth most at breast height and successively less at heights up to 20 and 28 feet. This reduction decreased stem taper.

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1953. Forest soil problem analysis on the Crossett area. U. S. Forest Serv. South. Forest Expt. Sta., 25 pp. [Processed.]

Discusses concern over site deterioration through continuous cropping of pines, removal of hardwood by fire or timber stand improvement measures, or by direct fire effects. There is no evidence of much effect on site by the first two, but where fire is frequent enough to keep the soil bare much of the time, physical deterioration may be rapid. Existing studies indicate only minor effects by single fires on water entrance into soil and on relative supply of nutrients in Coastal Plains soils.

Suman, R. F., and Carter, R. L.

1954. Burning and grazing have little effect on chemical properties of Coastal Plain forest soils. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 56, 2 pp. [Processed.]

After 8 years of grazing and several rotations of winter burning, soil organic matter, phosphate, and potash were practically the same as for ungrazed unburned areas.

——— and Halls, L. K.

1955. Burning and grazing affect physical properties of Coastal Plain forest soils. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 75, 2 pp., illus. [Processed.]

Volume-weight and water-absorbing properties of Coastal Plain soils are altered through compaction effects of grazing when litter is removed by burning.

Toole, E. R., and McKnight, J. S.
1955. Fire and the hapless hardwood. South. Lumberman 191 (2393) : 181-182, illus.
A 1,200-acre fire in November 1952 burned through a 70-acre experiment in the management of bottomland hardwoods. Losses included complete kill of trees up to 1 inch d. b. h., mortality of two-thirds of 1- to 2-inch trees, and 35 percent kill of 3-inch to 5-inch trees. With headfire or where there was logging slash, 90 percent of the trees over 6 inches were killed or severely damaged. Even where flames were least hot, losses of larger trees were 20 percent. Guides for salvage and for estimating extent of rot are included.

——— and McKnight, J. S.
1955. Fire damage to hardwood trees shown in Delta. Miss. Farm Res. 18 (9) : 1, 8, illus. *and* Miss. Agr. Expt. Sta., Serv. Sheet 432, 2 pp., illus.
Substantially the same as article cited immediately above.

Verrall, A. F.
1936. The dissemination of Septoria acicola and the effect of grass fires on it in pine needles. Phytopathology 26: 1021-1024.
Temperatures that kill needle tissue kill the brown spot in that tissue. Needles with scorched tips may have brown-spot infections in green basal portions after fire.

Wahlenberg, W. G.
1934. Dense stands of reproduction and stunted individual seedlings of longleaf pine. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 39, 16 pp., illus. [Processed.]
Longleaf seedlings may remain stunted for long periods in overdense stands, and be repeatedly injured by brown spot or fire. Brown spot tends to damage the larger seedlings, thus retarding expression of dominance, while fire often does more damage to smaller seedlings, thus promoting expression of dominance.

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1935. Effect of fire and grazing on soil properties and the natural reproduction of longleaf pine. Jour. Forestry 33: 331-338.
With fire protection, loblolly and slash pines become established on former longleaf lands. Ten years of protection affected physical soil properties favorably, but chemical properties unfavorably. Effect of 4 annual winter burns on longleaf cone production was negligible. Fire just before seedfall increased the number of seedlings that germinated and started growth. Fire 3 months after seedfall killed most longleaf seedlings. Neither complete fire exclusion nor annual burning results in satisfactory longleaf regeneration. Probably periodic controlled burning will improve longleaf seedling growth. See Wahlenberg, W. G., Greene, S. W., and Reed, H. R., 1939.

———
1935. Fire in longleaf pine forests. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 40, 4 pp. [Processed.]
Controlled burning may be used for longleaf seedbed preparation and disease control, and for hazard reduction in all southern pines, saplings and larger. Controlled burning requires planning and trained personnel, and benefits must be weighed against costs and damage.

———
1936. Effect of annual burning on thickness of bark in second growth longleaf pine stands at McNeill, Miss. Jour. Forestry 34: 79-81.
Two adjacent stands had been burned frequently prior to 1924. One was burned annually from 1924-34 and the other protected against fire. Measur

nents on 1,400 trees, from 2 to 8 inches in diameter, indicated that the double bark thickness of unburned trees was 0.066 inch greater than that of annually burned trees. Neglecting this bark difference might cause errors of 2½ percent in computed volume, but for most purposes the difference is negligible.

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1946. Longleaf pine. Pack Forestry Foundation, Washington, D. C., in cooperation with Forest Serv., U. S. Dept. Agr. 429 pp., illus.

This comprehensive monograph reviews all literature through 1944, and ncludes some otherwise unpublished information.

——— Greene, S. W., and Reed, H. R.

1939. Effects of fire and cattle grazing on longleaf pine lands as studied at McNeill, Mississippi. U. S. Dept. Agr. Tech. Bul. 683, 52 pp., illus.

Annual winter burning of uncontrolled intensity retarded growth of longeaf pine saplings by ⅕ in diameter and ¼ in height in a 5-year period. Neither annual burning, which defoliated seedlings, nor fire exclusion, which permitted brown spot to defoliate seedlings, was successful in bringing longeaf seedlings out of the grass. Burned-over soils had slightly more favorable hemical characteristics and slightly less favorable physical characteristics han unburned soils. Successful regeneration of longleaf pine where brown spot is present may depend on a system of periodic controlled burning. Annual vinter burning yielded better forage than did fire exclusion, which permitted pine litter and accumulated dead grass to reduce growth of grass and legumes and the number of herbaceous plants. On burned areas, cattle gained 37 percent more in 7 months of summer grazing than on unburned areas. Grazing affected compaction of surface soil about half as much as fire. With unburned and ungrazed areas as a comparison, unburned and grazed soils were 84 percent as penetrable; burned and ungrazed, 67 percent; and burned and grazed, 56 percent.

Wakeley, P. C.

1931. Effect of a single fire on planted slash pine. U. S. Forest Serv. Forest Worker 7 (2) : 11.

A fire in January 1930 burned half of a 4-year-old slash pine plantation about 8 to 9 feet tall. A year later, survival was 8.2 percent lower on the burned half and height was 1.2 feet less. The plantation was in south Mississippi.

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1931. The inside story of slash pine on areas subject to frequent fires. U. S. Forest Serv. Forest Worker 7 (1) : 11-12.

In southeast Louisiana, a good slash pine seed crop in 1924 regenerated ,000 acres of cutover land. The area had been frequently burned prior to his time but thereafter escaped fire until the winter of 1928-29, when most of it burned. Other fires the following winter finished the job, and today there s no visible evidence that the area was once well stocked with slash pine eedlings.

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1935. Artificial reforestation in the southern pine region. U. S. Dept. Agr. Tech. Bul. 492, 115 pp.

In southern pine plantations, longleaf is most fire resistant, slash next; oblolly and shortleaf are most readily damaged by fire. However, fire defoliaion generally causes a growth loss. All pines increase in fire resistance with ncreasing age. Generally, mortality for slash and loblolly in the first 2 or 3 years is essentially complete. Winter fires are less damaging than fires in the growing season. It is a moot question whether freedom from brown spot obtained by burning completely offsets the damage done by the fires themselves.

———

1944. Where and how can the pines be reproduced. South Lumberman 169 (2129) : 140-145, illus.

A survey in four widely separated counties in Alabama indicated (among several other minimum requirements) that freedom from fires for at least 5 years is needed to get adequate loblolly or shortleaf reproduction. See Brinkman, K. A., and Swarthout, P. A., 1942.

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1947. The 1947 cone crop and forest fires. U. S. Forest Serv South. Forest Expt. Sta. South. Forestry Notes 51 [Processed.] *Also in* Forest Farmer 6 (12): 5 *and* South. Lumberman 175 (2201) : 184.

To take advantage of the good 1947 pine seed crop, forest fires must be excluded until longleaf seedlings are at least 1 year old and other pines are 5 feet to 10 feet tall.

———

1954. Planting the southern pines. U. S. Dept. Agr., Agr Monog. 18, 233 pp., illus.

Longleaf is the most fire-resistant southern pine, slash next, and shortleaf and loblolly are the most easily fire damaged, but shortleaf up to 4 years old sprouts readily after fire. Planting site preparation by burning may not improve survival but may reduce planting and fire protection costs, and may retard brown-spot infection of longleaf and reduce rodent concentrations. But burning will kill small volunteer slash and loblolly, and may attract cattle to the area. Burning may also increase exposure to freezing or spring insolation. Prescribed burning of longleaf plantations for brown-spot control should be done in January or February before more than 35 percent of the needles are killed by the disease.

——— and Muntz, H. H.

1947. Effect of prescribed burning on height growth of longleaf pine. Jour. Forestry 45: 503-508, illus. *Also in* Naval Stores Rev. 57 (30) : 11, 24-25, illus.

A 40-acre longleaf pine plantation in central Louisiana established in 1935 was prescribe-burned January 1938, at which time brown-spot infection averaged 37 percent needle kill. It was burned a second time in February 1941. In July 1946, survival was the same as on a nearby unburned 60-acre plantation, but height growth on the burned plantation was far superior. In the burned plantation, 64 percent of the living trees were above 4½ feet in height as compared with 22 percent on the unburned. Much of the superior growth seems due to brown spot control by fire.

Wyman, L.

1922. Results from sample plots in southern pines experiments. Jour. Forestry 20: 780-787.

A report on 5 sets of plots at Urania, Louisiana, including the Robert plots, on which were observed the effects of annual burning (starting a year after germination) and fencing to exclude hogs. Hogs destroyed all longleaf on unfenced plots in the first year. The fires did not materially affect survival of longleaf but killed all shortleaf and loblolly. In September 1921, the 8-year old longleaf averaged 22 inches in height on the unburned plot but only 1[illegible] inches on the burned. The few trees killed by the January 1921 fire were practically all in the 6-inch to 18-inch height class. None over 2.5 feet in height was killed. The increased fire hazard on the protected plot was demonstrated by a breakover that killed or caused to sprout 39 percent of the trees as against 21 percent on the frequently burned plot (which had less fuel). Brown-spot disease weakens longleaf seedlings and kills some. Only 4[illegible] percent of the trees on the burned plot were diseased 9 months after burning as against 66 percent on the unburned plot. It is suggested this may be due to fire killing of diseased trees. See Bruce, D., 1947; and Hine, W. R. B., 192[illegible]

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

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OL. 18 A13321 JULY 1957 No. 3

FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 18 Number 3

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

FIRE CONTROL NOTES is issued by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (September 15, 1955).

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Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1957

CONTENTS

HOW TO USE CFFP MATERIAL

William W. Huber
Director, Cooperative Forest Fire Prevention

The Cooperative Forest Fire Prevention Program will be 16 years old in 1957. The theme of the '57 Smokey program is "Thanks folks for preventing forest fires." The "thanks" are in order too, because forest fires have been reduced from 210,000 in 1942 to less than 145,000 in 1956. During this time the use of our forests has increased threefold. Annual acreage losses due to forest fires have dropped from 32 million to less than 9 million.

Yes, it is timely to thank folks for preventing forest fires and also to thank the Keep Green Associations, the forest fire protective associations, and the many other organizations and industries that have made the reduction of fires and fire losses possible. But the job is not done; there is still much to do, and all CFFP materials must be put to the best use to keep the public alert to forest fire prevention.

The Smokey program is built around cooperation. The more people who help with the program, the more people who will prevent forest fires. Therefore, the program is aimed at mass education of the public by seeking all the help possible. Foote, Cone and Belding, Inc., of Los Angeles, Calif., is the advertising firm that is the task force for The Advertising Council, Inc., forest fire prevention campaign. This firm actually handled the program even before it was one of their regular accounts, since the plan to initiate a national-forest fire prevention program was written by Don Belding before CFFP was organized. We have some of the best help in the advertising business.

We have excellent distribution of material by T.V., radio, newspapers, magazines, bus cards, post office trucks, subway posters, and movies. This is made possible as a public service by The Advertising Council, Inc. But there is a weakness, and that is in the proper point-of-sale use of the material in localities where prevention is most needed. The printing of millions of Smokey posters, bookmarks, stamps, and booklets does not get the job done. This material must be displayed in the right places or put in the right hands and in such a way as to stimulate interest and respect.

Some ways to use CFFP items most effectively:

1. *Posters.* The posters are printed on paper and waterproofed cardboard. They are printed for use and not storage. The paper posters are printed for use indoors or where they have protection from the weather. The cardboard posters are used either inside or out. All posters should be replaced or taken down when weathered or torn.

The Government Printing Office prints the year for which the material is intended as follows: '57-CFFP-4a. There will also be ☆ U. S. Government Printing Office: 1957-O-367345, etc. The ☆=outside contract, not printed by U. S. G. P. O.; 1957=year printed; O=offset printing; and finally jacket or file number; but the main thing to look for is '57-CFFP-4b. This gives the year of

the CFFP program and the 4a or 4b stands for the item, number 4 being the rules poster and "a" meaning paper poster, "b" meaning waterproofed cardboard poster.

Display the paper posters prominently in all forestry buildings, and on bulletin boards, as well as in store windows, meeting halls, and under shelter on recreation areas. The rules poster for 1957 (fig. 1) has special appeal to conservation groups and school

FIGURE 1.—Rules poster.

groups and teachers. Put cardboard posters on panels and mount them on forest fire equipment or on outside poster mounts. But be sure to obtain permission to put up the posters on private property. This is also a good time to talk forest fire prevention. Posters are ideal for fair booths, exhibits, window displays, etc. Put them up carefully and take them down timely!

2. *Bumper strips* are for use on car and truck bumpers. Forestry agencies are encouraged to use them on all vehicles fore and aft. When sufficient supply is available, State police, game wardens, county agents, and county health people can be asked to use the bumper strips.

3. *Bookmarks, stamps, and calendars.* These items are termed handouts and as such do an important job. They are made for use by school teachers, business offices, banks, and store counters, and for mailing. The calendar fits desks in motels, hotels, offices, and schools. All letters mailed from forestry offices to the public should have Smokey stamps. Other conservation agencies and organizations should be encouraged to use the stamps. The bookmarks in '57 are larger and fit 9½x4-inch envelopes; they can be given to libraries and schools for use. Banks, churches, and places of business can be asked to distribute bookmarks.

4. *Easels and wobblers.* The easel should be used in Chamber of Commerce offices, airports, railroad ticket offices, school principals' offices, and forestry and other resource offices both public and private. Offices in county courthouses should have either the easel or wobbler. The wobbler (fig. 2) is smaller than

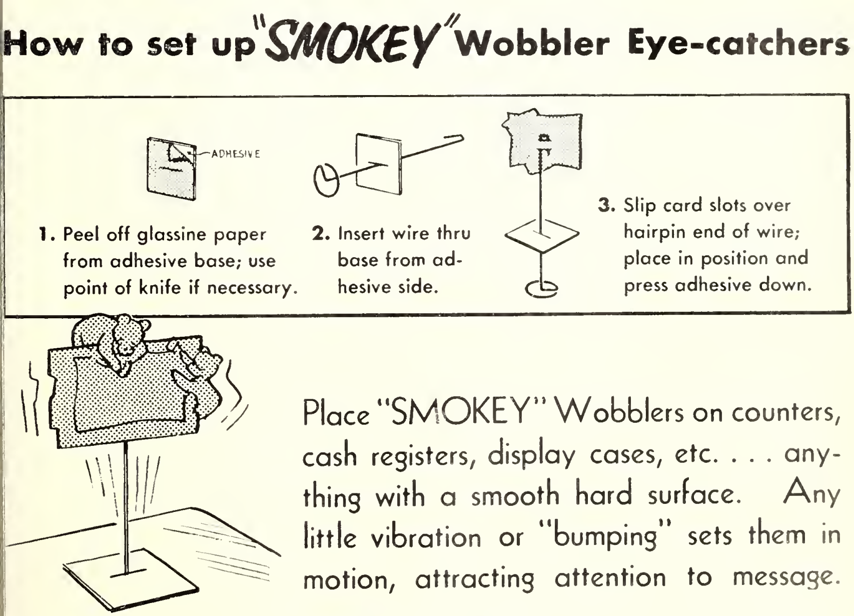

FIGURE 2.—Wobbler.

the easel and can be used at bank tellers' windows and on cash registers in sporting goods stores, and other stores and market places.

5. *Radio platters and TV spots.* The radio platters and the TV spot films (1-minute, 20-second, and 10-second animated cartoons of Smokey) are available through Smokey's Headquarters, U. S. Forest Service, Washington, D. C., or the State Forester's office. The Advertising Council, Inc., 25 W. 45th Street, New York City, arranges for support of radio and TV stations. Two television kits featuring the Smokey—Little Boy series will be sent out directly to television stations by The Advertising Council. Forestry personnel will be informed of these mailings so that they can personally contact the TV stations to stimulate the use of these TV spots.

6. *Newspaper ads.* The Advertising Council makes mailings of ads to newspapers, magazines, and house organs, but here again, personal contact of the local editors by agency representatives will get the job done. The Advertising Council is like an agent working for forest fire prevention; however, our people are on-the-ground performers who by personal contacts can use the ounce-of-prevention work that may save that pound-of-suppression work.

7. *Bus cards, three-sheet posters, and post office truck posters* are distributed by The Advertising Council, Inc., or by Smokey's Headquarters. A limited supply is available to foresters for display purposes. The bus or car card is used in trollies and buses. A supply is available for forestry agencies' use. The three-sheet poster has been popular for use at fairs and exhibits and on floats. When mounted on a cardboard, these make excellent displays. The post office truck poster is also ideal for display purposes.

8. *CFFP Material Kit.* This kit is used for distribution to large concerns, schools, conservation organizations, civic organizations, editors of magazines and newspapers, managers of radio and TV stations, and managers of timber associations and companies who are interested in forest fire prevention. They all have a vital stake in preventing man-caused fires.

9. *Smokey Bear Story of the Forest.* This booklet has been distributed to more than 4 million children. It is used as regular text in many schools. Schools and libraries will be glad to get this booklet, and rangers, district foresters, and fire wardens should all carry a supply.

10. *Other booklets.* Forest and Flame in the Bible and You and Forest Fires are also very popular and can be used in churches as well as schools. 4H, FFA, and other youth groups are making use of these publications.

11. *Junior Forest Ranger Kits.* These kits are distributed on request. However, the demand for them is now so great that we have asked radio and TV announcers not to mention that they are available. We have also discouraged magazine and newspaper ed-

itors from using stories about this phase of the Smokey Bear program. Nearly a million kits have been mailed since 1952. The youngsters are anxious to help Smokey and the field is wide open, but our present efforts in this respect must be limited.

12. *Special posters.* These posters hit at specific fire prevention problems. The debris or brush-burning poster is one example. The colorful 1957 range poster (fig. 3) aimed at the prevention of grass fires is another. We also have developed Red Cross posters, Girl Scout posters, Boy Scout posters and many other types of special posters. They are made for wide use and, although special in design, can be used in many areas. We wish to encourage more use of special posters, and we hope every forester will carefully review the new ones to see whether they meet some need in their area.

FIGURE 3.—Range poster.

13. *Commercial educational items.* Under the Smokey Bear Law of May 1952 (Public Law 359, 82nd Congress), the Secretary of Agriculture is authorized to enter into agreements with manufacturers for the use of the Smokey Bear symbol for educational items that will further forest fire prevention. The article must be in good taste and of high standards. Under this law, some 0 items have been licensed.

Some of the best sellers at present are Smokey Bear dolls, omic books, Golden Books, Smokey ash trays, tee shirts, blanets, scarves, and Smokey snuffers. These items are inexpensive nd very popular, and many conservation groups are using them

for promotional material. Lumber companies are giving out snuffers to interest people in forest fire prevention, and women's conservation groups are buying the Smokey Bear comic books at $6.00 per hundred for schools and libraries.

Other commercial educational items that are planned for 1957 are a Smokey badge, a new Smokey Bear doll, and a Smokey newspaper comic strip. The Fairmont Foods Company's product, Smokey's Maple Crunch ice cream, is very popular, and Fairmont Company is carrying on a nationwide program to find a name for Smokey's friend, a little fawn. This program is getting good coverage and creating interest in forest fire prevention.

The Smokey Bear program is now international; the Canadian Forestry Association has entered into a cooperative agreement to sponsor Smokey in Canada. Other countries have expressed an interest in similar agreements. The whole world is looking to us to make a success of the cooperative forest fire prevention program. Forest fire statistics will tell the story. Smokey has done a good job up to now, but a better job is needed. With more attention to the use of CFFP material, a better job can be done.

☆ ☆ ☆

Protect Tool Handles From Powder-Post Beetle Damage

For the past 4 years we have been successfully treating the handles of tools held in fire caches or storage against damage by powder-post beetles. Our treating vat is made of 2 pieces of 6-inch eaves trough soldered in the form a "T." One 6-foot and one 18-inch piece are used and the 3 ends are capped with regular end caps. The vat is so shaped in order to accommodate tools that are already handled. We use a commercially prepared solution that contains 4.37 percent pentachlorophenol by volume. The handles are soaked from 3 to 5 minutes in the solution and then stood on end for a few minutes. They are then ready for storage.

Our vat permits economical use of the solution and is adequate for district needs. If a larger vat were needed, it could be made from a split hot-water tank. Caution should be used in handling the pentachlorophenol solution because it is irritating to the skin and eyes.—JOHN D. WHITMORE, *Jefferson National Forest.*

AIR TANKERS—A NEW TOOL FOR FOREST FIRE FIGHTING[1]

JOSEPH B. ELY, *Fire Control Officer, Mendocino National Forest;* ARTHUR W. JENSEN, *Forester, Division of Forest Fire Research, California Forest and Range Experiment Station;* LEONARD R. CHATTEN, *State Forest Ranger, California State Division of Forestry; and* HENRY W. JORI, *Pilot, Region 5, U. S. Forest Service.*

Tactical air support for ground fire fighters is a step nearer to reality. Seven agricultural-type airplanes converted for bulk water drop became part of the fire-fighting force in California in August 1956. These planes fought 25 fires from Oregon to the Mexican border by cascading 100- to 150-gallon loads of liquid through a dump valve in the bottom of their belly tanks. The planes, flown by northern California agricultural pilots, made more than 1,350 trips and dropped a total of 83,120 gallons of water and 65,990 gallons of a fire retardant, sodium calcium borate mixture (table 1).

TABLE 1.—*Use of air tankers by U. S. Forest Service and California Division of Forestry,* 1956[1]

Date and place of use[2]	Name of fire	Water	Retardant	Total drops	Effect on fire[3]		
					Help	No help	Adverse
		Gals.	*Gals.*	*No.*			
8/12 Shasta Co.	Beegum #1	4,000	200	42	x		
8/20 Shasta-Trinity	Horr's Corner	910		8	x		
8/20 Lassen	Mill Creek	4,400		36	x		
8/20 Mendocino	Potato Hill	3,600		30	x		
8/20 Shasta-Trinity	Papoose Hill	600		5	x		
8/20 Shasta-Trinity	Cinder Cone		200	2	x		
8/22 Shasta-Trinity	Lava Cave	2,000	200	15	x		
8/25 Shasta-Trinity	Bohemotash	1,200	200	12	x		
8/26 Shasta Co.	Beegum #2	1,200	400	14			x
8/27 Klamath	Serpentine	2,520		21		x	
8/28 Mendocino Co.	Aero Stud	3,360		28	x		
8/28 Mendocino Co.	E. C. Anderson	240		2	x		
8/28 Mendocino Co.	Fomo Corp.	360		3	x		
8/29 Siskiyou Co.	Widow Springs	840		7		x	
9/9 Angeles	Dunsmore	4,560	80	39	x		
9/10 Cleveland	Pine Mt.	7,245	6,200	125	x		
9/11 Cleveland	Cornwell	13,225	6,100	176	x		
9/12 Riverside Co.	De Luz	460	200	6		x	
9/17 Lassen	Lodgepole	1,680		14	x		
9/21 Mendocino Co.	Public Domain	1,440		12	x		
9/22 San Bernardino	McKinley	24,480	25,400	458	x		
9/25 Riverside Co.	Potrero		700	7		x	
9/30 Shasta-Trinity	Steep Hollow	4,800	700	47	x		
11/23 San Bernardino	East Highland		2,410	26	x		
11/24 Cleveland	Inaja		23,000	252	x		
Total	25 fires	83,120	65,990	1,387	20	4	1

[1]Tabulation of reports from field officers of U.S.F.S. and C.D.F.
[2]Name of national forest for U.S.F.S. fires; county for C.D.F. fires.
[3]Definitions: "Help"—a deciding factor in assuring control of a definite help to ground forces. "No Help"—fire would have been controlled at same size without air drop. "Adverse"—put out backfire and made control more difficult.

[1]Presented at Air-attack Conference, Redding, Calif., April 10-12, 1957.

The air tankers made newspaper headlines during 1956, but their development was the culmination of an idea that began many years ago—as far back as 1921. Ever since then, fire fighters have tried to develop practical methods for dropping liquids on fires from aircraft. They tried dropping water in bombs or paper bags and uncontained from such planes as the B-29, DC-7, Ford Tri-motor, and TBM. None of these methods became practical. Some didn't work because planes weren't readily available. Some failed because too little of the water reached the ground.

Many of the problems were overcome, however, when modification of aircraft was turned over to agricultural aircraft operators who are highly skilled in low-level flying. In 1955, at the request of the Forest Service, the Willows Flying Service developed a practical, effective, economical method of attacking fires from the air.[2]

SCOPE OF 1956 OPERATIONS

To establish limitations of this new fire tool, the air tankers were used in as many fire situations as possible during 1956. They made drops under all sorts of conditions ranging from hot, rolling brush fires to small lightning fires in timber.

This was recognized as a trial-and-error operation in which air tankers might be ineffective or only slightly helpful. Yet air attack was a deciding factor in assuring control of 15 of the 25 fires on which tankers were used. Of the remaining 10 fires, air tankers were a definite help to ground forces on 5; they did not change the control picture on 4; and they caused the loss of line on 1 fire because the drop extinguished a backfire. Even on the 5 fires where the tankers didn't help, they emphasized some of the problems in their use and thus provided information helpful in later operations.

Air tankers attacked fires from less than 1 acre in size to more than 40,000 acres. On the larger fires, serious operational problems were encountered. These included supply and loading of aircraft to keep pace with demands, coordination with ground forces, and air traffic control.

To supplement the field reports of air tanker performance on fires and to calibrate the planes, a series of test drops were made at the Willows Airport in October 1956 (fig. 1). We wanted to learn the best combination of plane height, altitude, speed, gate size, and wind for dropping borate slurries. We also wanted to test and evaluate air-to-air and ground-to-air radio control. After the tests, air tanker pilots and representatives of the using agencies pooled their knowledge to draw up the rough operational guidelines presented here.

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[2]Ely, Joseph B., and Jensen, Arthur W. air delivery of water helps control brush and grass fires. Calif. Forest and Range Expt. Sta. Forest Res. Note 99, 12 pp., illus. 1955.

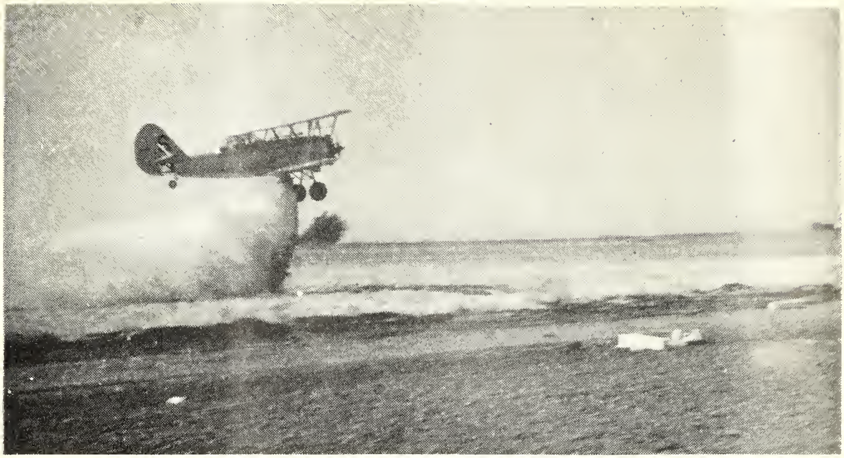

FIGURE 1.—Stearman air tanker making drop at 15 feet during October 1956 tests at Willows.

WHAT AIR TANKERS CAN DO

The 1956 experience left no doubt that water or a water and sodium calcium borate mixture dropped free-fall from aircraft can have a significant effect on grass, brush, and timber fires. Borate, because of its retardant qualities, does a better all around job than water.[3]

But air tankers with water alone can knock down fires in light fuels such as grass and young chamise. Here are some of the jobs air tankers can do:

1. Hold a small fire until initial attack forces arrive.
2. Cool down hot spots so that men can enter the area and work safely.
3. Knock down spot fires.
4. Build a fire-retardant line with borate in advance of a fire or where men cannot work (fig. 2).
5. Reduce the probability of crowning.
6. Strengthen existing firelines.
7. Directly support ground forces who are actively engaged in line construction.
8. Fireproof local areas where spot fires are probable, such as exposed slopes in steep canyons.

WHAT AIR TANKERS CANNOT DO

In some situations air tankers proved little or no help. They cannot:

1. Knock down hot rolling brush or timber fires.
2. Safely make drops in high winds (over 30 m. p. h.).

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[3]MILLER, HARRY R., AND WILSON, CARL C. A CHEMICAL FIRE RETARDANT—RESULTS OF FIELD TRIALS USING SODIUM CALCIUM BORATE ON FOREST FIRES IN 1956. Calif. Forest and Range Expt. Sta. Tech. Paper 15, 19 pp., illus. 1957.

3. Make drops in the bottoms of steep canyons or other inaccessible places.
4. Cool down hot fires in heavy fuels under timber stands.
5. Work at night.

FIGURE 2.—Air tanker drops 100 gallons of sodium calcium borate on Inaja Fire, Cleveland National Forest, November 1956.

OPERATIONAL GUIDELINES

Four to six Stearman air tankers make an effective, manageable air tanker squad. If possible, they should be led by an experienced fireman in a reconnaissance plane.

Effective length, width, and concentration of the drop pattern vary with plane, height, speed, altitude, gate size, and wind direction and velocity. To obtain the greatest concentration of liquid on the ground, the airplane should fly level and as low and as slowly as conditions will permit and as nearly into the wind as possible. The more rapidly the liquid is released the greater the concentration will be. Increasing the drop height, air speed, or dropping in a cross wind will give greater area coverage, but will reduce concentration. Drops from more than 100 feet above the vegetation will usually be wasted. With a cross wind of more than 10 m. p. h., there is little chance of hitting any part of the target. Experienced air-attack pilots can achieve higher concentration by dive bombing or banking releases.

AIRCRAFT AND EQUIPMENT

Air tankers must be in top mechanical condition and have a reserve of horsepower. Minimum tank capacity for drop liquids should be about 50 gallons. The tank should be accurately calibrated and properly vented. One square inch of vent for each 5 square inches of gate area allows unrestricted gate flow. The gate should have a minimum opening of 175 square inches for plane speeds up to 110 m. p. h. and tanks up to 200 gallons. The gate size should be larger for higher dropping speeds. A free-swinging (hinges at leading edge), quick-release door seems to be most satisfactory (fig. 3). The pilot should be able to close the gate while in flight.

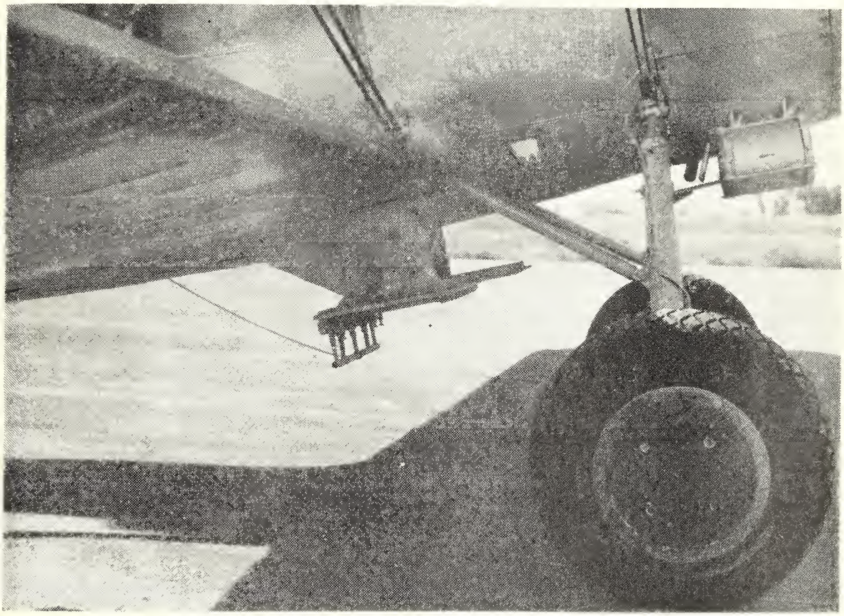

FIGURE 3.—Typical release gate (175 sq. in.) in belly of Stearman air tanker. Note release cable.

PILOTS

Until pilot qualifications are more firmly established, the following specifications are to be used:

1. At least 1,000 hours of flying time including either 500 hours of agricultural flying or 200 hours of spraying, cargo dropping, seeding, baiting, fish planting, or similar low-level mountain flying experience.
2. A performance test will be made with a series of water drops in various maneuvers. At least 5 drops should be made before a pilot is allowed on a fire.
3. A 1-day pilot training program will be conducted each spring or early summer to familiarize new pilots with operational procedures and fire-fighting tactics.

GUIDELINES FOR PILOTS

The ultimate aim is to fly as low and as slowly as is safe. Generally, this means 80 miles per hour at about 50 feet above the fuels. Here are other simple rules for air-attack pilots:

Check air hazard map.—Check the local air hazard map for the drop area. It will show the locations of power lines, telephone lines, and other safety hazards.

Make a dry run.—On new targets make a dry run at a slightly higher altitude than intended for the drop. This is specially valuable where downdraft or restricted visibility is anticipated.

Watch visibility.—Avoid continuous straight flight in poor visibility. When forward visibility at the airport or over target area is less than 1 mile, air tanker operations should stop.

Use visual signals.—A system of air-to-air and ground-to-air visual signals should be prearranged for use when radio communications fail.

AIRPORTS

For smoothest operation the airport used should have a minimum of air business—preferably with little or no commercial traffic. The whole air tanker operation can be jeopardized if proper facilities are not provided at the airport. Such things as the right kind and amount of gas and oil, high-rate delivery pumps for gas and water, adequate borate mixing equipment, a large supply of water, and even proper threads on hose and pipe fittings are important. When chemical retardants are used, mixing demands can be high. Each hour more than 2,800 gallons of retardant will have to be mixed to supply a 7-plane squadron operating on a schedule of about 10 minutes round trip from the fire. This means 47 gallons of mix must be available every minute.

COORDINATION WITH THE GROUND ORGANIZATION

Like any other specialized tool, such as bulldozers, plows, or tankers, air tankers must be closely coordinated with other fireline action. Effectiveness depends almost entirely on timing and accuracy. Direct air-to-ground communication is a MUST!

Rarely will the air drop alone be sufficient to put out the fire. It must be teamed with adequate ground forces. Thus, except in holding action, the ground forces should be in place before drops are made. Occasionally it may be necessary for the man on the ground to guide the tankers to low visibility targets, as in smoked-in areas. One important point to remember is that free-fall drops of water or sodium calcium borate are not harmful to personnel. The target area need not be evacuated.

Air drops must be accurate. Since single drops made at 50 feet elevation and 80 m. p. h. have a limited pattern (fig. 4), there is little room for error. This factor has to be considered for any given fire situation in deciding deployment of the available aircraft. Sometimes air tankers should be "stacked up," waiting for the right time to attack as a team. At other times they should attack individually.

CONCLUSIONS

The air tanker, as fire-tested in 1956, has won its place in the fire organization in California. But many questions still need to be answered:

How much water and chemicals penetrate various cover types and cover densities?

What are the relative merits of various sizes and type of planes?

How can we best distribute or concentrate planes for initial attack?

How can we make the best tactical use of many planes on large fires?

Even after these problems are solved, tactical support by air tankers cannot replace all the ground fire fighters. Instead, this specialized attack makes men on the fireline more important and more effective. Control lines and thorough mopup are still necessary. Gains made by fast air attack can be lost if firemen on the ground can't recognize critical changes in fire behavior and take full advantage of a knocked down fire.

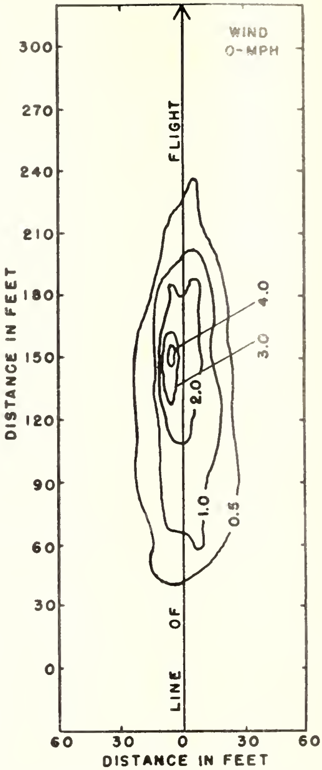

FIGURE 4.—Typical pattern for 100-gallon borate drop from Stearman air tanker with large gate (175 sq. in.) and flying 50 feet above the ground at 80 miles per hour. Contour lines show borate concentration in gallons per 100 sq. ft.

TEMPLATE AIDS INSPECTION AND MAINTENANCE OF 3½-POUND DOUBLE-BIT AXES AND PULASKI TOOLS

L. DON WILLIAMSON

Spokane Warehouse, Northern Region, U. S. Forest Service

During various inspections made of axes and pulaski tools in our Spokane fire cache, and at other field headquarters, it was found that visual inspection only was resorted to, with much discussion as to whether or not a tool was satisfactory and should be discarded or resharpened. The accuracy of the decision varied between individuals, upon the amount of time each person allotted to each tool, and many other factors. Many instances have been found where worn out and unsafe tools have been maintained and used, and where tools still possessing satisfactory life have been set aside for condemnation.

No one was using a physical or material guide that would be of satisfactory accuracy to form the basis for determining action. A listing of the specifications, a rule, and their application seemed to be the nearest system and this was time consuming and seldom used.

Most axes and pulaski tools are of bimetallic construction. According to their specifications, the bit steel is overlaid and welded to the body. This steel extends only 1/2 inch to 5/8 inch back from the cutting edge of the tool, and when this has been expended, the tool should be discarded.

To take advantage of this fact, a template was constructed at the Spokane Warehouse (figs. 1 and 2). It is made of 1-inch lumber, and is most useful assembled on a base at a 45-degree angle. As yet we have not provided for the measurement of the hoe shank, but this can easily be added. One board or template is used for both tools. The cost is approximately $15.

"A" and "B" on each template are rests to hold the tool in proper position. The pulaski tool must be properly handled so that the handle fills the eye at point of support "A." The wood in the ax eye must not protrude through to keep the ax head from resting on the supports in an even position. The wooden template is hollowed out to fit the shape of each tool head. The template and stand are painted white with black lines and lettering. Red denotes unsafe area, and black safe or good steel area. When a tool

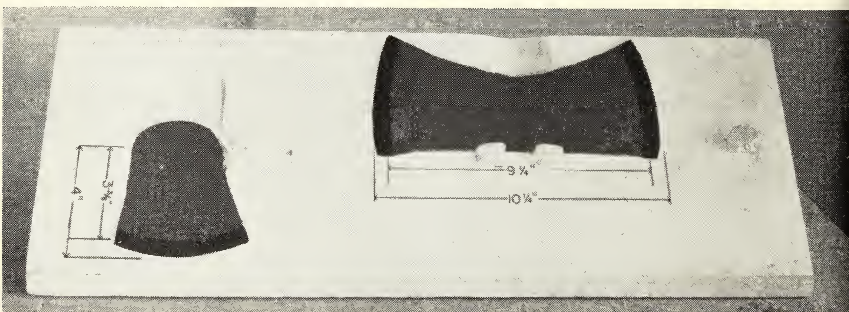

FIGURE 1.—Template; black edge denotes safe sharpening area.

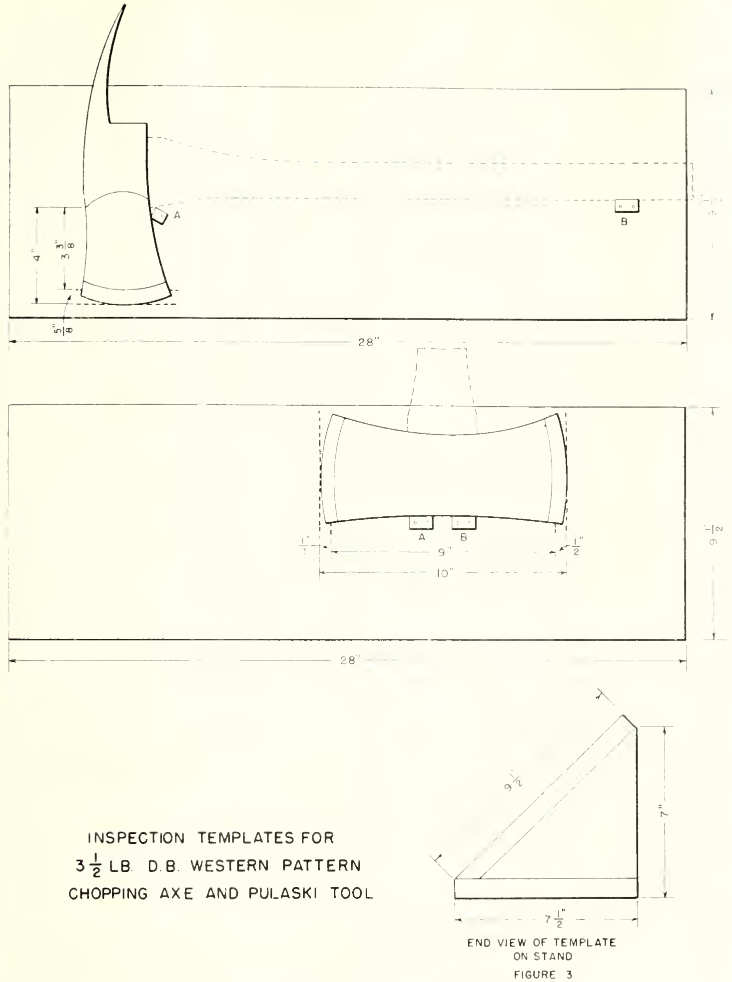

FIGURE 2.—Template measurements.

is in position, if red shows it denotes unsafe or unsatisfactory conditions which should be given careful consideration.

The use of this template at the Spokane Warehouse has taken the guesswork out of the tool sharpener's operation. He still must use his expert opinion to varying degrees, but he has a definite base to work from. Inspectors and supervisors also have a common base (visual aid) to work from in discussing work standards with employees, and it is of invaluable aid in training new and emergency employees. Besides indicating whether or not a tool is worn out or unsafe and ready for the scrap pile, the template is used as a guide in reshaping and sharpening. Our most skilled workmen accept it as a very useful working aid. Tool maintenance and inspection has been speeded up about 10 percent through the use of this template.

PRESCRIBED BURNING TECHNIQUES IN LOBLOLLY AND LONGLEAF PINE ON THE FRANCIS MARION NATIONAL FOREST

JOHN T. HILLS
Forester, Francis Marion National Forest

The results obtained by the use of prescribed fire are determined largely by the recognition of existing conditions and by the skillful application of fire. Much has been learned through the extensive use of fire under a combination of various conditions and methods of application. If consideration is given to all factors influencing a fire, the results of a prescribed burn always come closer to what is wanted than would otherwise be the case. Some of these factors are season of year, amount of fuel, fuel moisture (upper and lower layer), temperature, wind direction and velocity, and days since one-half inch or more of rain.

Several cardinal points should be considered just before and during the use of fire:

1. Get the latest weather report.
2. Remember that a constant wind strong enough to direct the fire is necessary for control.
3. Begin burning on the downwind part of the area to be burned.
4. Fire is best kept under control by fire itself—offensive action often eliminates defensive ones.

Through trial and error several techniques in applying fire under a given set of conditions have proved successful on the Francis Marion.

Checkerboard or spot firing.—The checkerboard technique is best suited for use in stands 20 years and older, medium rough (2-3 years), wind 3-5 miles per hour, temperature around 60° F. After establishing a safe line of fire on the downwind side of the area to be burned, the method consists of setting a series of spot fires in checkerboard design parallel to the baseline. The distance between the spots and their size can be varied according to the factors at hand. The advantages to be gained by using this method follow: (1) It is safe (as far as the use of fire goes). The fires compete for space and fuel, and before any damage can be done both have been consumed. (2) A clean and complete burn is assured. (3) A minimum amount of fireline construction is necessary. (4) The number of men to be used is not limited. (5) Large areas can be burned quickly—before weather conditions change.

Strip burning.—The method of burning in strips is very adaptable, and can be used in all age classes large enough to be burned. It consists of setting a series of solid lines of fire parallel to the baseline. This technique can be used effectively to kill undesirable hardwood (summer or winter fire), reduce heavy rough (as soon after rain as rough will burn), and control brown

spot, where flames should reach needles 3 feet or more from the ground. The advantages are that the intensity of the fire can be controlled by varying the distance between lines of fire in proportion to amount of fuel and the size and density of undesirable hardwoods to be killed. The advantages mentioned under the checkerboard technique are also obtained.

Flanking fire.—When the head of a wildfire is stopped, two flanking fires remain for a time. Fire fighters having experience in fire suppression in the Coastal Plain region probably have observed that such fires are very effective in killing undesirable hardwoods and removing heavy rough with little or no damage to the pine. This flanking type can also be used on an area to be prescribe burned by building the fire in the shape of a right triangle, the base of which is downwind. It is similar to a backing fire but burns much faster and cleaner.

Before selecting one of these plans of action, the land manager should consider the advantages of each method in relation to the results expected.

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Illuminated Poster

Designed by C. A. Rickard, Flathead National Forest, Kalispell, Mont.

LINEN HOSE SURVIVES THE FIRE

Arcadia Equipment Development Center, U. S. Forest Service

On September 21, 1956, 1,500 feet of new linen hose was laid by a helicopter on the McKinley fire, San Bernardino National Forest. It was charged and put into service as part of an extended hose lay along a ridgetop fireline (fig. 1). The remainder of the lay was CJRL.

FIGURE 1.—Fireline along ridgetop. McKinley fire, 1956.

At noon on the following day, the fire flared up out of a brushy canyon and spotted over the line onto the slope on the other side. The tanker crews were forced to abandon the hose and several thousand feet of it, including the linen, was subjected to the full heat of the fire. Burning embers fell on many sections of both cotton jacket and linen.

We were curious to know how the new linen hose survived this practical heat test. Since all of the linen hose had the date 1956 stamped on it, it was easily identified. We were able to account for all 1,500 feet. None of it was destroyed; none was burned through although it was badly scorched in numerous spots.

Damage to the CJRL, however, varied from small burned holes to holes 3 to 6 inches long. There were many lengths that had evidently burned like a fuse. All that was left of them were short pieces and a black residue along the ground (fig. 2).

FIGURE 2.—Part of the remains of CJRL hose used on the McKinley fire.

We brought the worst scorched of the linen hose into the Arcadia Equipment Development Center, and on October 17 it was pressure tested. It burst at 450 p. s. i., but surprisingly the burst did not occur at any of the scorched spots (fig. 3). This would indicate that the fire had not necessarily weakened the hose. In fact this hose compared favorably with hose not used on the fire which burst at 440 to 450 p. s. i. Previous tests in the laboratory have shown that linen hose when charged is extremely fire resistant, a very important factor in maintaining pressures on long hose lays.

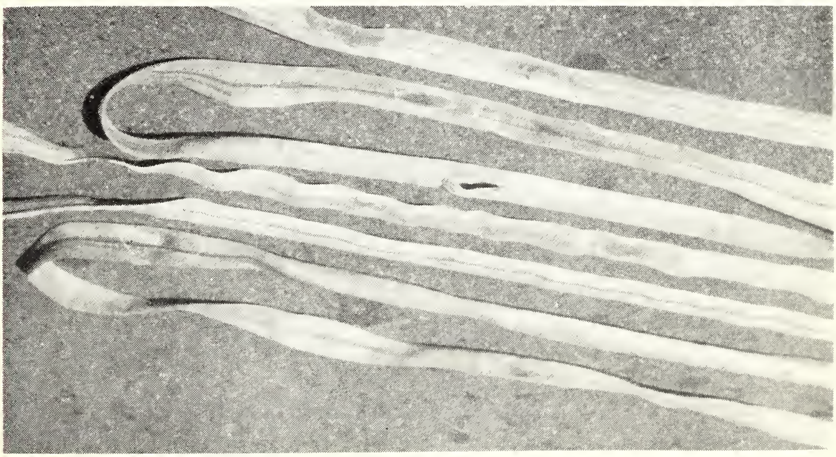


FIGURE 3.—Linen hose that survived the McKinley fire and was later pressure tested. Note that it did not burst at scorch spots.

USE OF POWER SAWS IN FIRELINE CONSTRUCTION

Edward E. Bailey
Associate State Forest Ranger, California State Division of Forestry

Within the past few years lightweight power saws of various types designed for brush removal have been developed and placed on the market. Lacking a standard of performance or sufficient operating data to properly support field purchase requests, a test program was conducted to compare and evaluate representative groups of gas and electric saws. These machines were tested for use primarily in fireline construction on terrain not negotiable by bulldozer, and the results were compared with those of hand crew line construction.

Three circle type saws, three bow type saws convertible to a bar type, and two electric saws with a 1500-watt generator were secured (fig. 1). The test was expected to show if the generator when not being used with the saws could serve as a standby unit for a fire camp or supply additional light for night fireline power saw operations.

Two sites in Humboldt County on California's north coast were chosen as test areas. Species cut by the saws were blueblossom (*Ceanothus thyrsiflorus*), tanoak (*Lithocarpus densiflorus*), Pacific madrone (*Arbutus menziesii*), redwood sprouts

Figure 1.—Test crew personnel and saw types tested. (California Division of Forestry photo.)

(*Sequoia sempervirens*), blackberry (*Rubus vitifolius*), Willow (*Salix* spp.), and poison-oak (*Toxicodendron diversilobum*). Elevations were from 950 to 1,450 feet. Slopes ran from 0 to 105 percent.

To arrive at a statistically significant figure, 1,575 plots would be required with 10 saws. On 7 slope classes 1,540 plots in 3 densities (light, medium, and heavy) were cut with 8 saws (fig. 2).

FIGURE 2.—General view of brush types on test areas. (California Division of Forestry photo.)

The personnel was divided into 4 crews composed of operator, tallyman, and observer. Each operator was assigned a test site, and all saws were rotated to that operator in the particular site. The man assigned as operator remained at that job for the 10-day period to eliminate as much as possible the human element. The tallyman measured the diameter of all stems cut and recorded them by basal area on the proper form. The observer measured out the plots and kept the record of time for each plot with a stopwatch. Each saw operator had 2-4 California Department of Corrections Honor Camp Inmates assigned as brush swampers and helpers. A saw filer and mechanic were assigned to the test also.

For each slope in his assigned site, the operator ran strips of 15 plots up and 15 plots down with each saw. The plots contained 50 square feet and were 5 by 10 feet or 10 by 5 feet depending on

the saw being used. On the third day all plots were changed to 10 by 5 feet since a 10-foot-wide line made for easier and safer operation (fig. 3).

In evaluating the saws for hand crew line construction, lines were cleared to mineral soil in these tests. On the saw operation alone the line was not cleared to mineral soil.

FIGURE 3.—10-foot fireline, showing typical brush and debris, rock, and slope encountered on test sites. (California Department of Forestry photo.)

From the statistical data it appears that the circular type saw will produce the most work in average brush areas. However from observance the bow type saw would be the most adaptable in heavy stands of diameters 4 inches or larger.

Although there were no accidents, the test personnel was of the opinion that the circular saw was a potential hazard to ad

jacent workmen. Operating techniques were controlled accordingly. Nevertheless, the overall performance of this type of saw still showed its superiority. This could have a bearing on ultimate tool selection or the possible need for restricting the use of these saws to experienced personnel only. Consequently a "power head" to which both types of saw could be adapted would meet the largest variety of conditions with which we are faced.

Contrary to what was originally expected from electric saws, their light weight and size actually proved a disadvantage and forced the operator to expend more energy in pushing the saw through the stems and in kneeling to reach the stems to be cut. The generator was not easy to handle on steep slopes or rocky ground; it required two men in constant attendance to keep the generator moved up and the cords untangled from cut stumps.

For data control purposes, line widths were originally determined to be 5 feet. After operating 2 days (406 plots), it became necessary to widen the lines to 10 feet for more space to swing the circular type saw and to provide safer working conditions for the swampers on all types of saws. Data were still collected on a square-foot basis and showed no material difference in area cleared. But for safe operation the data are sufficient to be considered in determining ultimate line widths in actual fireline operation.

Some work was done to evaluate the usefulness of the power saws at night in brush and to determine if additional light was required. This test project did not show that night operations were materially slower than day work. Observation revealed that the crews worked with added ease when 150-watt floodlights were mounted on the generator with the electric saws. It was concluded that the standard Forester headlight should be supplemented by additional light source.

The data disclosed that there was little difference in the production rate of uphill vs. downhill work. This was due to the added difficulty in cutting stumps low enough when going downhill, offsetting any natural slope advantage.

From observations made during the test and from analysis of the collected data, probably the best crew size for power saws, excepting the electric saws, would be 6 men, i. e., 1 operator, 2 swampers, and 3 men clearing the line to mineral soil. The production rate of such a crew with a power saw in brush under average conditions could be compared favorably to that of a hand crew of 10 to 12 men.

One method of weight control used by the manufacturer is the size of the fuel tank supplied and designed for his specific unit. Of the saws tested, fuel capacities varied from 1 pint to 1 quart. This factor should be considered very important in adapting power saws to fireline construction, since during the test, operating time varied from 1/2 to 1 hour per tank of fuel. It is therefore imperative that a supply of properly prepared fuel be readily available.

ADMINISTRATIVE PICKUP FIRE FIGHTING UNIT

State of Washington, Division of Forestry, Fire Control

Washington's Division of Forestry uses half-ton pickups for its district wardens and assistants. The usual practice is to load the box of these pickups with cement blocks, rocks, or old iron to give weight and make the pickup ride better. Fire Control decided that since some inert ballast was going to be carried around regardless, the weight might as well be useful for fire suppression and thus increase the striking force on fire throughout the State.

This decision resulted in a 67-gallon pumping unit that costs approximately $200. The unit is comprised of a small rectangular tank 18 inches square and 4 feet long which sits just aft of the pickup utility box where the warden carries his gear (fig. 1). Its entire weight, plus a tank full of water, is approximately 732 pounds. Half the pickup bed is still free for other hauling.

The tank is plumbed to the fan-belt drive pump under the hood by flexible, high-pressure hose. Female couplings are used on both ends of the hose to expedite easy removal of the unit. The discharge is plumbed from the pump back to a bypass on the tank through a similar hose. With this arrangement the discharge hose is connected to the bypass on the tank, and it is not necessary to lift the hood to connect a discharge hose or engage the clutch.

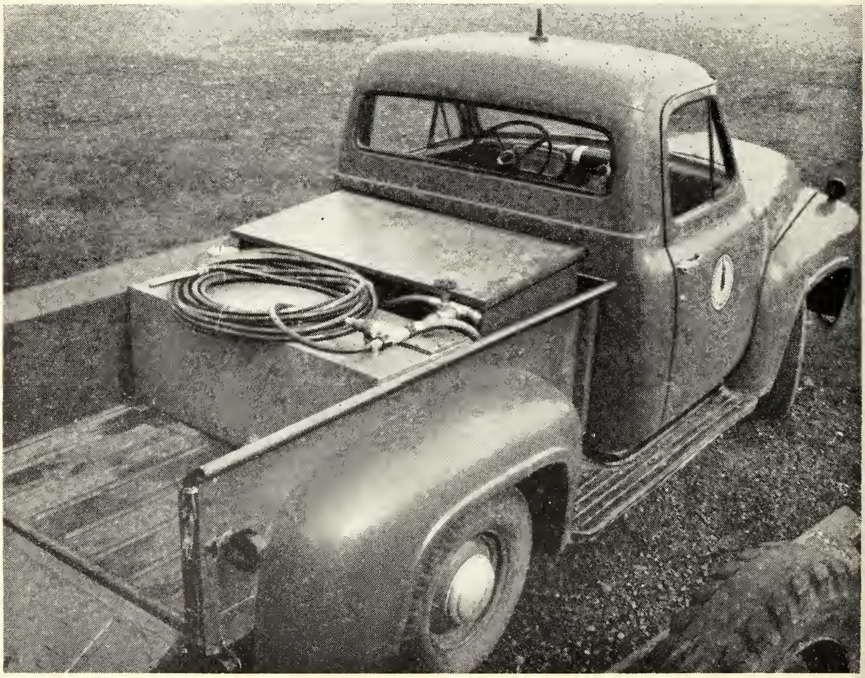
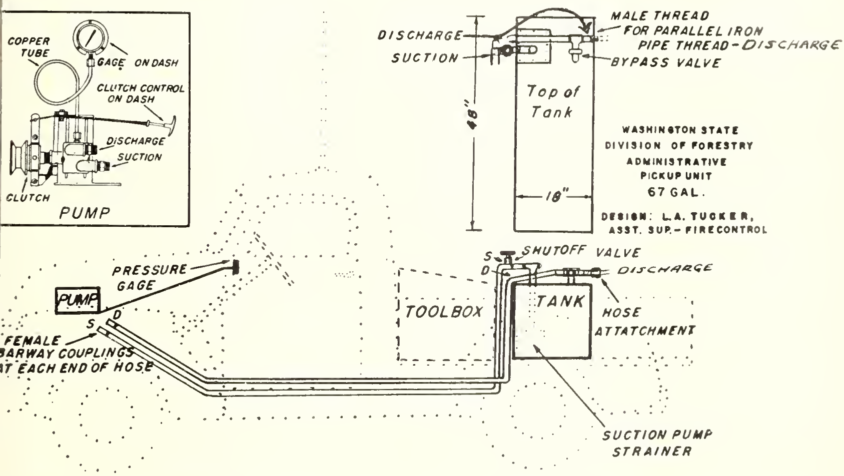


FIGURE 1.—Half-ton administrative pickup equipped with a 67-gallon slip-on unit mounted back of utility box.

The pumping unit is a gearless-neoprene or carbon-impeller ype that is capable of pumping from 5 to 19 gallons per minute, lepending on the r. p. m. Its initial cost is reasonable, and any ieeded repairs are quite inexpensive. Power is taken from a louble pulley on the generator through a split V-belt pulley clutch fig. 2). With this type of clutch the sides of the pulley are spread part, and when the pump is not in use, the belt runs on an idler n the center of the pulley. This idler has sealed lubrication. When he clutch is closed, the sides of the pulley are brought together, hus picking up the V-belt and the power to drive the pump.

The clutch is controlled from the dashboard through a flexible ontrol wire. A pressure gage is also mounted on the dash. The perator can start his pump before getting out of the cab, because he bypass device works as long as the nozzle is closed. The bypass s set to operate at 100 pounds pressure on the gage when the ngine is a little more than idling, and the pump delivers about 8 allons per minute at this speed. One man can handle this mahine efficiently. The unit does not have a live reel, but one is lanned that will carry approximately 200 feet of single-braid, ieoprene, one-half inch, ID water hose.



IGURE 2.—Schematic location of 67-gallon slip-on unit, pump, pressure gages, plumbing, and shutoff and bypass valves on ½-ton administrative pickup.

Fire control did not design the slip-on unit to take the place of major pumper, and it is stressed in training that this unit must iot tie up potential overhead that should be leading others in the ontrol of a fire. However, since all of our pickups are equipped vith mobile radios, they are often the first piece of equipment o arrive on many of the small fires. They are able to take care f these fires in the incipient stage without the dispatching of ther equipment.

AIRPLANES AND FIRE CONTROL IN THE SOUTHWEST

FRANKLIN O. CARROLL
Assistant Fire Staff Officer, Coconino National Forest

Because airplanes have been used only sporadically in fores fire control for many years in the Southwestern Region, grea opportunities remain for perfecting and intensifying their use The Coconino National Forest in Arizona used airplanes exten sively for the first time during 1956. Prior to that time, it ha used planes occasionally to scout blind spots and to drop messages maps, and supplies to remote fires and fire camps. A stead drying trend in the past few years and an increasing number o large fires caused us to take a new look at the airplane as a too in prevention, detection, and suppression work in our region. Th following resume is based on our first year's experience.

Prevention.—Psychology plays a very important part in fores fire prevention. For example, forest users generally feel that low-flying patrol airplane offers a very tangible warning. I order to gain the greatest benefits from this method of fire pre vention, it is necessary to advise the forest-using public by radi and newspaper that such a method will be used. The use of air borne loudspeaker systems has also proved fairly effective. Whil the broadcasting range of this device is limited, it is adequate fo short fire prevention warnings.

Detection.—We do not believe that fire detection from air planes will ever completely replace stationary lookout systems We do believe, however, that the use of airplanes is necessary t supplement fixed detection. Observation from planes has prove very effective on the Coconino during periods of heavy smoke an haze, after lightning storms, and during periods of heavy fores use. Northern Arizona is particularly subject to hazy atmospheri conditions during certain of the summer months when smoke fror forest fires and dust blanket the country.

Normal detection flights cover areas that are blind to lookouts These flights are also effective for the investigation of areas re ported by the fixed detectors as suspect. The most effective aeria observation is made in the early morning or late evening whe the sun's rays are more or less parallel to the earth's surface. Th flight pattern should keep the area to be observed between the air plane and the sun as much as possible. As many persons know, smoke may be more readily seen when the observer is looking int the light. Once pinpointed, the fire is then accurately reported t the central dispatching agency. Aerial observers on the Coconin were selected who had sufficient experience to enable them to siz up each fire situation and order adequate suppression action.

Suppression.—The Coconino National Forest has had an average of 385 fires per year for the past 5 years. Record highs ave exceeded 700 fires. In 1956, it had 502 forest fires, 86 of which were man-caused. Man-caused fires have averaged 85 per ear, a significant number in view of the fact that forest use is stimated to have tripled in the past 5 years. Our objective has een to hold the burned-over area to 880 acres. In 1956, 1,100 cres were burned. Since only one fire burned more than 300 cres, we believe that early aerial detection and fast suppression ction have reduced the average size or area burned in each ire.

The total number of fires first discovered from the air was reater than those first discovered by any of the lookouts ex-ept one. Observers in planes, using two-way radios, guided re crews to difficult-to-find and remote fires. By "talking" the re crews in to fires, the aerial observers saved a great deal of me and expense as well as acreage burned.

A constant source of accurate information from an aerial oserver has helped many a fire boss make effective decisions in ne strategic handling of large fires. During a 2-day, 99 lightning-re "bust" in late June 1956, our observer utilized his lofty posi-on to dispatch and guide crews and equipment to individual res and to determine which fires required immediate attention r could be safely handled later. This alone saved many acres.

Finally, parachute supply operations have proved their worth me and again in fire control. We use planes for dropping pur-oses whenever conditions, terrain, and time warrant. Aerial ipply methods have been extremely effective. Without doubt, the rplane is taking its rightful place as a common tool of forest re control in the Southwest.

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Dunk That Chunk

Ray West, Supervisor, Anaconda Forest Protection Service, figures that o matter how muddy water gets, it's still wet. West's idea goes still further that he makes just a little bit of water go a long way in the mopup pro-dure of fighting and beating forest fires.

In West's country, just over the Continental Divide from Anaconda and e Big Hole country of Montana, water is at a higher than usual premium n most of the fires. West has made several used 2- to 5-gallon paint pails a art of the regular equipment on each fire truck in his organization. The pail, sed as a dunking utensil, takes up where the hose and pump leave off.

Dunking takes all of the fight out of the usual burning debris near the reline. Later when it's possible to get inside the line to work on stumps, tten logs, and other accumulations, a man with a "dunking pardner" can scourage any ideas a hot spot might have about making something big of self.—ROBERT JORDAN, *CFM Forester, Montana.*

CAP DESIGNED TO COVER ACCESS HOLE IN ROOF OF TOWER CAB

H. H. GARTH
Chief, Division of Forest Protection, Virginia Division of Forestry

Rusty lookout tower cabs and cab roofs are unsightly and pre sent a maintenance problem. To remedy this situation, the Vi ginia Division of Forestry undertook a cab painting project. Th first attempt proved to be dangerous and time-consuming. Climb ing, rope ladders, window scaffolds, long-handled brushes, an paint rollers were used in that attempt.

It was decided that a hole in the center of the roof, larg enough to permit a man to crawl through, might be helpful. B experimenting with an exhibit tower trailer, the Division deve oped a method of cutting the hole, reinforcing the tower roo and fabricating a cap.

To cut the hole, a saber saw was first tried with a small d. generator serving as a source of power. This method required sev eral hours of hand sawing. To expedite the hole-cutting job, a acetylene torch was used. Where towers were accessible to ve

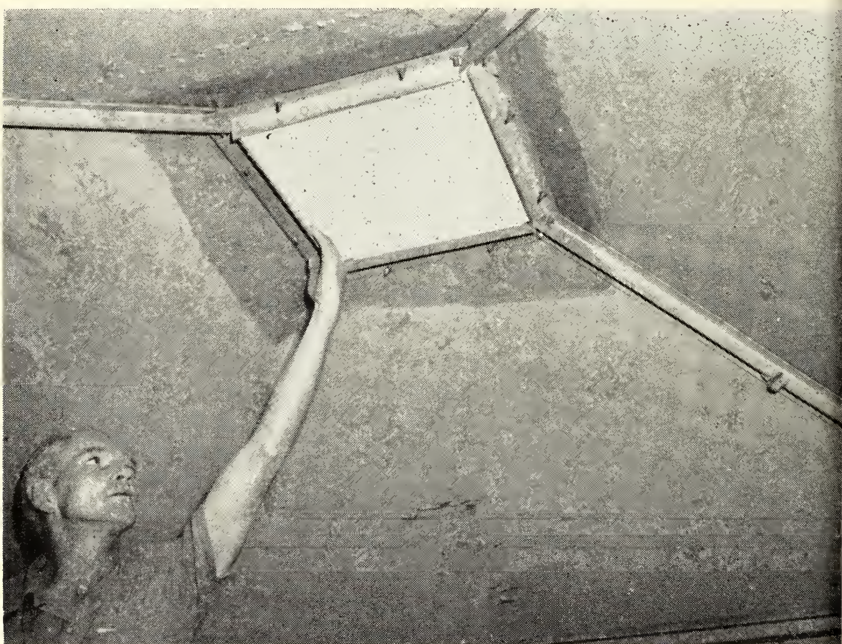


FIGURE 1.—Cab roof reinforced by bolting 1-inch angle iron to edges 18-inch hole.

hicle travel, the gas tanks and other equipment were easily brought in to the site. Most of Virginia's towers are between 80 and 100 feet high, and there is no problem in obtaining hose long enough to do the job.

Although the hole was made with an acetylene torch in a matter of minutes, the torch has one big drawback. The heat generated destroys the galvanized coating on the cab. The Divis-

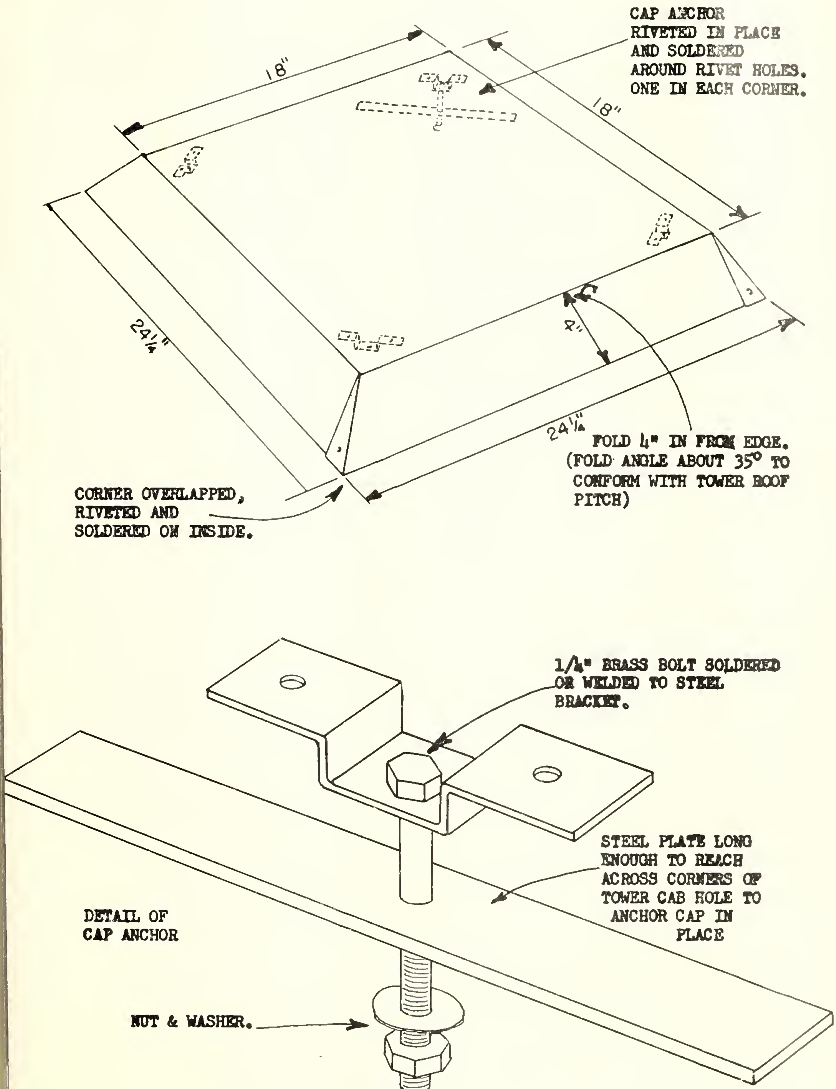


FIGURE 2.—Schematic drawing of cap to cover access hole in roof of 7- by 7-foot tower cab.

ion is still undecided as to which is best—the fast cutting torch or the slower cutting saber saw that protects the galvanizing.

The hole, 18 inches square, is reinforced with 1-inch angle iron bolted around inside edges (fig. 1).

The prefab cap is made of 26-gage galvanized metal cut to a 26- by 26-inch square. Cuts are made on a 45° angle from each corner to a depth of approximately 5½ inches. The corners are lapped and riveted and the joints soldered on the inside. Quarter-inch brass bolts are welded to small prebent pieces of steel (fig. 2). The steel, with bolt attached, is then riveted to the cap and the rivet holes soldered on the inside. This method is preferred to either soldering or welding the bolt heads directly to the cap; welding has a tendency to warp the metal and destroy the galvanized coating, and soldering does not appear to be strong enough. Small pieces of steel are bored (5/16-inch holes) to serve as anchors. The cap is then ready for mounting.

To fit the prefabricated cap in place, a rope is tossed out through the hole and permitted to fall past a window. The cap is then tied to the rope and hauled up onto the roof. The cap is squared over the hole, the anchors run up on the bolts, and the nuts tightened behind them. The cap will not go through the hole in the tower roof, and if the hole is enlarged there will be less cap overlap to keep out the weather. Gaskets, made of old linen hose, are fitted around the edge of the cap to prevent wind and water leakage.

Prior to bolting the cap in place, the cab roof is wire brushed and painted with aluminum paint. A metal tray and fleece-covered roller are used to do the painting. This same unit is used to paint the outside of the cab simply by reaching through the open windows.

THE GORDON BADE WATER RAKE

R. E. Reinhardt
Forester, Division of Timber Management
Washington Office, U. S. Forest Service

Experienced fire control men who have used the water rake believe it is a practicable and worthwhile water-saving device. It is recommended for use where water is scarce and in deep duff where water penetration is slow. One water rake is recommended for each tanker unit in areas where council tools are standard fire fighting equipment.—Ed.

The economical and effective use of water for fire mopup has been a problem. Often pumpers are employed in mopup long distances from sources of water. It is usually necessary to stretch the pumper water supply when putting out fire in duff and debris with nozzle and high pressure. More often than not inexperienced nozzle operators aimlessly squirt water at smoking debris only to have the fire come alive later and escape.

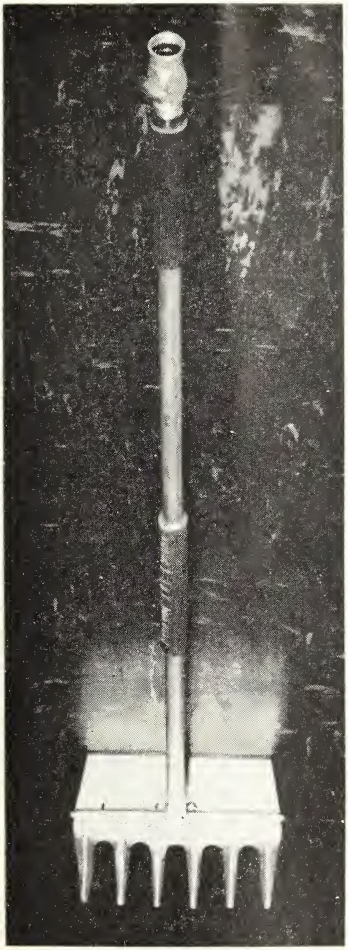


Figure 1.—The Bade water rake for mopup.

The mixing of a little water with duff and debris is one of the most effective and economical ways of extinguishing fires in this material. The usual practice is to have one man mix the smoldering duff and debris while another applies water to it until the fire is out. Although effective, this method requires two or more men.

Various devices have been tried to eliminate this dual use of manpower. Among these is a nozzle temporarily fastened with rope to the handle of a Kortick blade that deflects the stream on the ground while the operator rakes and stirs the smoldering debris. This is an effective method but awkward and laborious. The nozzle is generally insecure, and it is difficult to coordinate nozzle control with the raking action. The water under high pressure occasionally backfires and splashes the operator with water and debris.

Gordon M. Bade, Timber and Fire Staffman on the Kaibab National Forest in Arizona, fabricated a device almost 20 years ago which is slowly gaining acceptance as knowledge of its effectiveness spreads by word of mouth from one forest to another (figs. 1 and 2). The end of a hollow handle is attached to a hose. Water flows through the handle to a lateral distributor pipe with

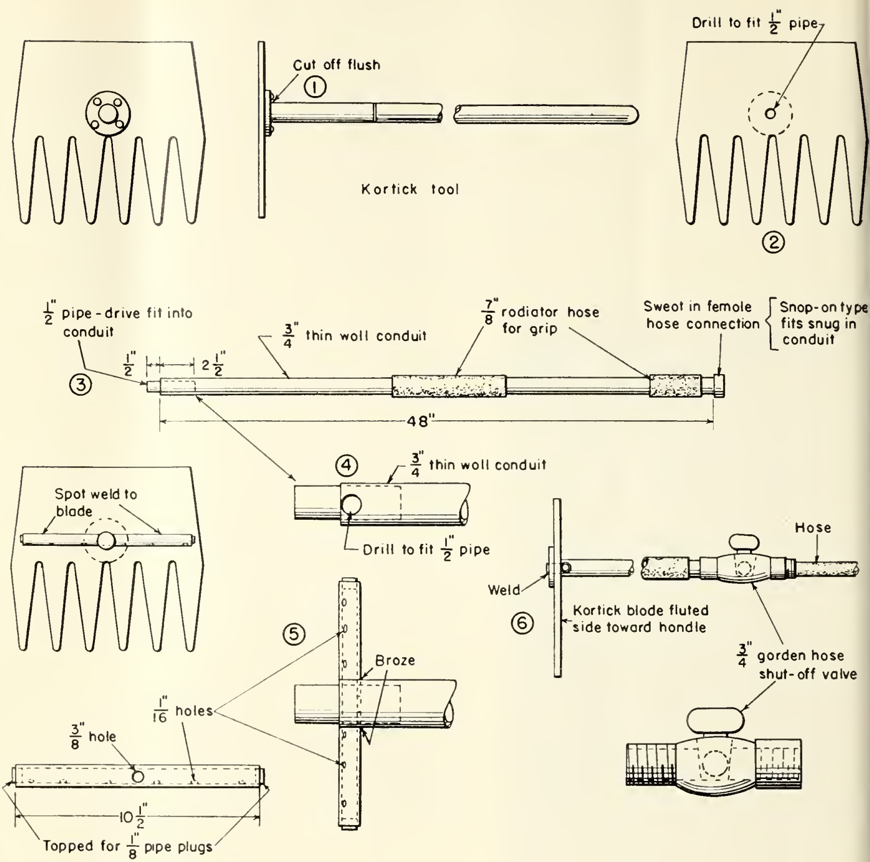


FIGURE 2.—Diagrammatic drawing of the Bade water rake.

small holes in it lined up with the concave teeth of a Kortick tool. The volume is controlled by a thumb value at the end of the handle. This tool is effective with low pressures and will use less water if the pump pressure is cut. An adaptation of this device to be used with a standard backpack pump might be feasible.

Component parts of the Bade water rake and instructions for assembling them follow:

Parts

1. 1 Kortick tool.
2. 4 feet of ¾-inch galvanized thin wall conduit.
3. 10½ inches of ¼-inch galvanized pipe.
4. 2 ⅛-inch pipe plugs.
5. 3 inches of ½-inch galvanized pipe.
6. 1 standard female brass garden-hose adaptor. (The snap-on types, available at hardware stores, fit snugly in the thin wall pipe and make sweating-on with solder an easy matter.)

7. 1 garden-hose shutoff valve. (A better device would be a thumb-control pressure valve.)
8. 18 inches of 7/8-inch radiator hose for handle guards. (Metal pipe is cold when held for prolonged periods.)

Assemblage

1. Saw the shank off a Kortick tool as close as possible to the blade.
2. Drill a hole through the blade at the center of the shank flange to fit the ½-inch pipe.
3. Drive the short piece of ½-inch pipe into one end of the thin walled conduit, leaving about ½-inch protruding.
4. Drill a hole through the thin walled conduit and ½-inch pipe to admit the ¼-inch pipe. Edge of the hole to be flush with end of thin wall.
5. Drill a 3/8-inch hole through one side at the center of the ¼-inch pipe.
6. Drill 1/16-inch holes through the wall of the ¼-inch pipe at points which center the rake teeth. The best way to do this is to run the ¼-inch pipe through the hole in the thin wall handle, center it with the 3/8-inch hole headed up the handle. Then assemble the blade and handle to determine the angle of the 1/16-inch holes to assure delivery of water down the fluted teeth. Cut down rivet heads if they interfere with delivery of water down teeth. Disassemble and drill holes in the wall of the ¼-inch pipe.
7. Tap both ends of the ¼-inch pipe for 1/8-inch pipe plugs and insert them. These will provide for cleaning the pipe if the pipe or holes become plugged.
8. Assemble pipe in proper position and braze small pipe to conduit. Attach to blade and braze or weld shut and to the blade the end of the ½-inch pipe that protrudes through the blade.
9. Spot weld ¼-inch pipe to blade to keep it in place.
10. Slip about a foot of 7/8-inch radiator hose, for a hand grip, onto the handle a little below the middle of it. Slip another 6-inch piece on at the end. The hose will fit tight and can be rammed down into place with a piece of 1-inch pipe slipped over the conduit.
11. Sweat on the female hose connection at the end of handle. (Run the 6-inch piece of hose down the handle while soldering the female hose connection to keep from burning the rubber, then return it to the top.)
12. Attach shutoff valve.

This tool has proved particularly handy for raking coals off logs and simultaneously extinguishing them. One of Bade's more rugged guards has suggested this device might be handy for the Saturday night bath.

PRESCRIBED BURNING IN SHORTLEAF-LOBLOLLY PINE ON ROLLING UPLANDS IN EAST TEXAS

E. R. Ferguson

East Texas Research Center, Southern Forest Experiment Station

Large test burns on rolling uplands in east Texas have proved quite variable and only moderately effective in controlling undesirable hardwood understory. This is in contrast to encouraging results achieved with prescribed fires on small plots in the same general type.[1] Runoff and surface soil movement on two diverse soils were little affected by these single fires.

THE STUDY

Twelve fairly uniform units were established on the Neches District of the Davy Crockett National Forest. The units, averaging about 190 acres each, were in a shortleaf-loblolly pine sawlog stand with a medium to heavy brush-hardwood understory.

The units were paired according to similarity of topography, overstory, and understory. This provided 6 pairs of units, 2 of which were randomly assigned to each of 3 seasons of burn. One unit of each pair was randomly selected for burning and the other was left unburned as a check.

Ten sampling points were systematically located within each unit, and at each point one 1/10-acre plot and one 1/250-acre plot were established. Stems on these plots were inventoried before and after the prescribed fires.

Burns were made in November 1952, March 1953, and April 1953. Burning on all units followed the same pattern. Lines were plowed and fire was set along the leeward boundaries, following which the flanks and finally the windward boundaries were fired. As time permitted, supplemental lines of fire were started through the interior of the units.

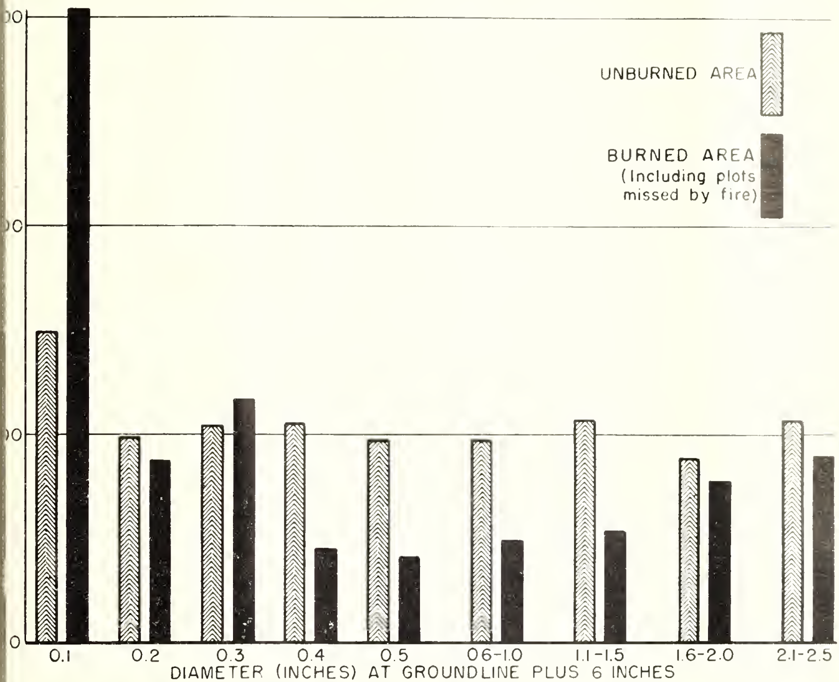
On selected units, burned and unburned, hydrological test areas were located on the prevailing soils, Boswell fine sandy loam and Lakeland fine sand. These were 4- by 20-foot runoff plots with metal borders, located on gentle (5 to 8 percent) and moderate (11 to 16 percent) slopes. They provided weekly records of surface runoff and a cumulative record of soil loss.

RESULTS

The prescribed burns were only moderately successful in controlling the undesirable hardwoods (fig. 1). The number of stems ½ to 2 inches in diameter was reduced 1/3 to 1/2, but these re

[1]Ferguson, E. R. stem kill and sprouting following prescribed fire in a pine-hardwood stand in texas. Jour. Forestry 55: 1957. (In press.)

luctions were largely offset by an increase in sprouts and root uckers. The result has been a moderate, but probably temporary, eduction in understory volume.



IGURE 1.—Hardwood stems after treatment, shown as percent of number on plot before treatment.

There were no differences in effectiveness between burns made 1 the three seasons tested.

Failure to achieve greater reduction in small hardwoods was 1 part due to the light and variable nature of the prescribed urns. Only about 80 percent of the area within the burning units as actually burned, and less than half of that was covered by a edium or severe fire. On limited areas with severe burns, there as some loss of sawtimber pines. Such divergent results reflect e widely varied burning conditions that occur on extensive areas f rough terrain. To approach the effectiveness demonstrated on mall plots, prescribed burning will require much closer control ith resultant higher labor costs and equipment expense.

The single fires of the study had little effect on surface water unoff and soil movement from the hydrologic test plots. On the akeland fine sand, the prescribed burns had too little effect on ifiltration rate to be reflected in runoff. On the Boswell fine andy loam, burning appeared to increase runoff slightly. There as little difference in runoff on slopes ranging from 5 to 13 ercent.

Soil loss was light on all plots (table 1) and safely below the maximum erosion rate permissable on watershed lands.

TABLE 1.—*Soil loss per acre /18 months*

Treatment	Lakeland fine sand		Boswell very fine sandy loam	
	Slope	Soil Loss	Slope	Soil Loss
	Percent	*Tons*	*Percent*	*Tons*
Burned	8	0.14	5	0.73
Burned	12	.11	11	.28
Unburned	8	.15	6	.17
Unburned	15	.16	13	.13

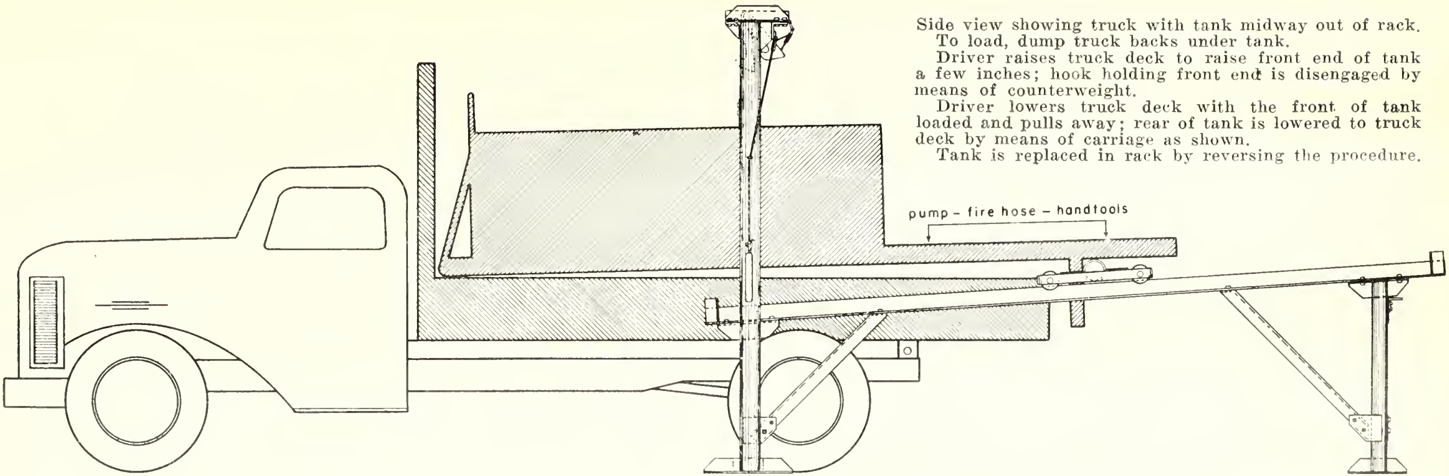
The possibility that more severe or repeated fires could have more serious effects should not be overlooked. The test plots still had 1/8 to 1/4 inch of litter after the fires. With complete exposure of the mineral soil, both runoff and erosion undoubtedly would have been much greater.

☆ ☆ ☆

Fire-Danger Board

Designed by R. T. Files, Glacier Ranger District, Glacier, Wash. (For specifications, write to author.)

Self-Loading Tanker Unit (Patented)



Side view showing truck with tank midway out of rack.
To load, dump truck backs under tank.
Driver raises truck deck to raise front end of tank a few inches; hook holding front end is disengaged by means of counterweight.
Driver lowers truck deck with the front of tank loaded and pulls away; rear of tank is lowered to truck deck by means of carriage as shown.
Tank is replaced in rack by reversing the procedure.

Here is a device by which any open-end dump truck can smoothly and automatically pick up a load of more than 5 tons in less than 1 minute without the driver leaving the truck. He can also unload in a like manner.

The truck is not tied up with the tanker unit until fire occurs. When the fire is over, the unit is replaced in the rack and the truck can resume its normal duties. The rack holding the unit is bolted together. It can be quickly taken down by two men, moved, and set up in another area as the hazard dictates. During high-hazard periods, the truck may remain parked under the unit, relieved of the strain of heavy load yet ready for instant action.

Provisions were made to chain this unit to the truck when loaded. Chaining is unnecessary. however, when strips of rubber from a used tire are attached to the bottom. The friction holds the unit even on rough roads and in hilly country.

When a truck capable of carrying more than 5 tons is tied up with a tank, the various uses of a very expensive piece of equipment become restricted. We believe that in capacity, getaway time, and ultimate function, the self-loading unit is equal to the regular tanker, yet the self-loader has a greater economical advantage.—WM. EDEN, *Assistant Fire Marshal, Marathon Corporation of Canada Limited.*

RURAL PUBLIC RELATIONS[1]

The People Side of the Large-Scale Forestry Operation

GLENN R. DURRELL
Head of Department of Forestry, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma.

As a basis for understanding some of the public relations problems that harass the forester or manager of a large forest property, let us take a look at the situation from the standpoint of the rural citizen who lives as a neighbor to the operation.

This citizen is a member of the community. His thinking is a part of public opinion. He makes up the juries that try our cases in court. He elects the people that make and enforce our laws. His needs for public services influence our tax rates. He may be part of our labor supply and one of the consumers of our product. He uses our land for recreation, for forage, for fuel, sometimes for protection from erosion or flood damage. He is a free man. He respects himself and his family. He likes to deal with the boss rather than with hirelings. He has the same wants, the same basic human urges, drives, compulsions, that the rest of us do. He is fearful of the unknown, he is inclined to resent and distrust bigness. Numerically, he out-votes us. Generally he or his ancestors were here before we were and had established use rights long before we attempted management of our forests.

He is as law-abiding as we are—that is, law-abiding according to his own code, which may or may not resemble in all respects the laws on the statute books. The code he follows, however, fits his own needs and is generally accepted, and enforced, by him and his neighbors.

We can ignore his needs and feelings, stand on our rights under the law—and remain unwanted aliens in his country, or we can attempt to understand him, respect his situation and perhaps—certainly slowly—gain his good will and acceptance into his community.

As foresters we like to feel—and often boast—that well-managed forests make major contributions to the welfare of the individual and the community. We are often surprised and are usually disappointed to find that relations between large ownerships, public or private, and their rural neighbors may deteriorate rather than improve as forest management is intensified. This deterioration may be expressed in many ways. The most common, of course, is the setting of fires. Others are timber theft, destruction of fences and other improvements, lack of support in law enforcement, election of county and state officials opposed to what we consider progress, inequitable tax assessments, violation of understandings and so on. Why should this be when managed forests mean more jobs, more income, community stability, etc.?

[1]Reprinted by permission from the December 1955 issue of *Southern Lumberman.*

STAGES OF FOREST DEVELOPMENT

We are taught in our study of forest history that the stages of forest development are the same in all countries. The nomadic man gathered his living where he found it. The domestication of animals and the beginning of agriculture put pressure on the forest for space for pasture and crops. Then the development of the crafts led to local exploitation for special products. Machinery and transportation extended the scope and area of exploitation. Then tree culture and finally management develops. Most of us overlook a principal point to be gained in the study of history; we assume that we are at the beginning of intensive management—and, as far as some of the forest lands are concerned, we are. The important point, I think, is that man has always used the forest to meet his current needs—and that these needs, these several stages of forest development, can exist side by side, as far as our neighbors are concerned, on a relatively small forest property. One of our neighbors needs the berry crop, or mast for game and hogs; another more pasture or more land for crops; a third wants special products from the forest for his particular craft; still another wants work to eke out his livelihood, and he wants to stay at home, not move to town or to the next county.

Another point that should be stressed in our study of forest history, and a study of our own behavior should point out the same thing, is the strong foundation in our thinking of rights developing through use. Some of this system of establishing rights through use has found its way into law—squatters' rights, public thoroughfares, acquisition of water rights through beneficial use, for example. To bring this closer to home, think for a minute of the use rights that you possess and would raise a fuss about if they were threatened; your desk, other office furniture, the company car assigned to you, tools and equipment, your space in the parking lot.

A related idea, that one individual or corporation should have no more of basic resources than he can use is firmly fixed in the public's thinking and many examples of this also can be found in our laws. Our public land disposal policies, some escheat laws, limitations on the amount of land to be irrigated by individuals on Bureau of Reclamation projects, the perennial attempts to pass graduated land tax laws are examples. Perhaps our graduated income tax laws, although theoretically based on ability to pay, are also a reflection of this same idea.

A human trait common to most of us, even those of us who consider ourselves civilized and law abiding citizens, is the habit of using land, space, resources, that do not belong to us if the rightful owner does not appear to be using the property for the moment, or if other non-owners are using the property. What happens to an abandoned farm, for example? What goes on in the vacant lot in your town? It is a depository for unwanted trash and a source of soil if you need it. It is a playground for the neighborhood. What happens to junk and garbage if your town does not have an adequate collection system?

WHY RESENTMENT

With these gleanings from history and human nature—that human needs in an area can vary greatly, that we instinctively fear bigness and try to limit it, and that we are inclined to use that which isn't being used—let us review our activities in the light of the individual neighbors involved to see if we can find answers to the question of why, if good forestry practices are so beneficial, they may stir up resentment rather than support.

We started out with acquisition, the building up of holdings. In this process (except in the creation of the forest reserves by withdrawal from public domain) we dealt with the citizens as an equal. We became acquainted with him and his family. Because travel was usually on horseback or on foot—distances were relatively great—we took our meals with the family and spent the night in his house. We accepted his hospitality. We brought him news from the outside world. We discussed our work and our plans with him. Our money for his timber improved his lot. We were taking off his hands something that he couldn't use and that we thought we could at a price both parties considered fair. He didn't care much who owned the vast wooded areas around him—one non-resident owner was as acceptable as another—and perhaps the new owner would do something with the land. We often told him to help himself to fuel wood, to graze the forest, even to leave his buildings or occupy a favored spot on our lands—all we were interested in was the mature timber of certain species and we might not cut that for twenty years. In fact, we often bought the land only because we couldn't acquire the stumpage without it.

These concessions, freely made, and usually not formalized by written agreements, were transferred to new owners as rights when land changed hands. Others decided that if it was all right for one man to use company land it must be all right for them to use it too. As these use rights passed to new owners or to the next generation in a family they became more firmly established in the minds of the owner. Any limitations, either terminal or provisional, that might have been included in the discussion at the time the original concession was made became inoperative because they were not exercised and hence ceased to exist.

TREADING ON TOES

When we started logging it was a progressive operation. As we pushed our railroads and spurs back into the timber the local resident came into contact with another group of our employees. This group had a job to do and they were rated on their ability to get the logs out of the woods at the lowest possible cost. Some of them in their zeal to do a good job, as rated by the cost standard, trod on the toes of the local citizen. The concentration of people in the logging camps sometimes depleted the local game and fish supply which the citizen regarded as his own. Right-of-way problems for the spurs arose. Logging roads created erosion problems. Log hauling on local roads through all kinds of weather tore them up and made them almost impassable to the or-

inary farm wagon. Some felt that they had to sell their timber 'hile the logging was going on in the area because they might ot have another chance, and because this situation existed many elt that they had lost part of their bargaining power and hadn't ot as much for the timber as it was worth. They began to feel ie bigness of the outfit and to resent somewhat the fact that ioney was being made out of cheap stumpage. As the logging ront passed on some of the neighbors followed the job, often aving too few people in the settlements to support schools, iurches, roads, and the crossroads store. The woods were left full : tops, and slash which constituted a fire threat to grass, rail ences, and buildings. This had to be burned for protection, and illowing the logging and fire, brush and reproduction came in ireatening the grass crop. This led to further burning in a losig battle.

When we decided that there might be a future in holding our it-over lands for future crops of trees, these fires could no nger be tolerated. Fire laws were passed which, in effect, made 'iminals out of people who felt that they were only protecting ieir firmly established rights. We employed wardens and rang-'s, built towers and telephone lines. Some of our lines were built ider contract. The contractor, in order to make the maximum 'ofit also at times made enemies for us by promising phones for ght-of-way, by cutting trees that the citizens valued, by swing-ig the line over roads and trails to avoid clearing, by placing the nes too close to buildings. His job was to get the line in as ieaply as possible—not to win friends and influence people. Re-rictions on the use of the lines also made enemies. Generally 'forts were made to get emergency calls through but there was uch difference of opinion over what constituted an emergency.

As state protection agencies developed, the fire job was trans-erred to their hands and another contract between company and tizen was broken. Gradual abandonment of telephone lines in ivor of radio also has left some individuals and communities ithout contact with the outside world.

With the decision to practice forestry, residual stands became ore important and valuable both as a seed source and as a base ir the next cut. Trespass men were needed to protect this re-iurce, a resource that as far as the local resident could see was ot being used. Some of our trespass men too lost much of their 'fectiveness and their standing in the community by their own olation of other laws.

AREAS OF CONFLICT OPENED

As our forest management work was intensified, more areas : possible conflict were opened. Newly planted areas had to be rotected from excessive grazing. Both the planting and the ecessary fencing eliminated grazing land to which the local cit-en felt that he had an established right through long use. Timber and improvement work meant, to the local citizen, a reduction : hog and deer feed in the woods, fewer den trees, fewer bee 'ees.

Increased costs of the forestry program dictated more inten sive use of the land. Idle acres became an expensive luxury. W began to look at the adverse uses (many of them freely grante during the acquisition program) to see if they could be eliminate or made to pay their way. Since no record had been made of earl promises and many of the men who had made them had passe out of the picture, difficulties in adjusting these uses on an equit able basis were bound to arise. The grapevine carried the new from one area to another. A fence removed in one area becam company support for a general stock law by the time the new had made the rounds.

The development of the forestry program also brought change in the company representatives who deal with the loca people. The foresters have entered the picture—young, enthusias tic, anxious to make a showing—and for the most part, foreig to the local people and their ways of life. They understand littl of company background and history and less of past dealings wit the neighbors. Practically all of them have immediate militar backgrounds with emphasis on unquestioned following of order rather than on finesse in dealing with people.

The citizen sees more of this young man as he passes up an down the road—not as a neighbor but as a threat to his security The forester is a busy man. He doesn't have time to stop an visit, to take a meal or spend the night. His contact with the citi zen is apt to be brief and businesslike. His activities arouse sus picion and since he seldom takes the time to explain why he i doing the things he is, and what he expects to do next, the citize must speculate and put the news on the grapevine to be distort ed as it is repeated.

Now, what can we do about it? How can we extend the ad vantages of good forest practices to the rural citizen as well as t our urban neighbors? We must remember first of all that there i a basic difference between many of our rural people and those wh have adapted their lives to the ways of town where wants ar satisfied by earning money with which to purchase materia things and the pleasures that represent a comfortable living. Th rural citizen often has an entirely different set of values. One o the most important of these is freedom: freedom to go where h pleases, when he pleases, space in which to live; freedom to mak his own decisions; freedom from bosses and time clocks and mi whistles. Money is important, of course, but to many it is a sec ondary consideration. We must remember that they may not war to be woods workers or forest farmers; that they like their wa of life; that they don't want things changed. Particularly, the do not want to lose use rights that have been theirs for genera tions.

MARKING OF BOUNDARIES

How do we go about establishing actual as well as legal title t our property? It is generally agreed that the marking of bound aries is a helpful first step. There is a right way as well as wrong way to go about this simple job. If the avowed purpose is t establish lines that will save time and money on future operation

imber cruising, logging operations, protection, etc., if it is the ntent to keep our workers off the lands of others it will be ac- eptable. If, on the other hand, the job is approached from the tandpoint of, "This is our land. Keep off", resentment is sure to ollow. The line marking crew is also in position to hear first- and of adverse uses, of boundary disputes, of rights granted by ormer employees, etc. These should be recorded and reported s a basis for further action. A next step toward acquiring act- al ownership might well be the formal recognizing of uses of ur lands by others by written documents. This can be done from he standpoint of protecting the user in his right by making it a atter of record so that future employees will recognize it. At he same time it establishes the fact of ownership and the right to rant or reject such uses. Such agreements can have a terminal ate requiring renewal or relinquishment. When once placed in riting the use ceases to be inheritable property.

It might be a good idea to take an inventory of uses or needs hat exert pressure on the forest property—uses and needs of ru- al neighbors and communities. Fitting in as many of these needs nd uses as can be tolerated without undue cost or adverse effect or establishment of questionable precedent) on the forest would e a good investment in public relations. The job must be done on businesslike basis, not with a paternalistic attitude, if it is to be ffective. In general our experiences in buying cooperation with oncessions has not been too rewarding.

RECREATIONAL USE

It would be well to recognize that the public at large will never urrender recreational use of forest lands regardless of owner- hip. Watershed influences are probably in this same category. Ve will have to recognize these public uses and make room for hem in our planning. If we do not, we can expect, eventually, he exercise of the right of eminent domain, or legislation that vill protect these rights for the people. In the main these uses vill not conflict with the management use of the forest except or the added fire risk. Studied effort on our part might provide or these uses on an acceptable basis. At the same time it is uestionable whether the development of recreational areas for ublic use on private property is the answer. The damage to tree rowth in areas of concentrated human use is great and the up- eep of such areas in an acceptable condition is a constant job nd a heavy expense.

A next step in acquiring rights in our own land is evidence f more intensive use of that land. A twenty-year cutting cycle for xample, may be reasonable on a large property but to the neigh- oring landowner twenty years with no activity on the area is a ong, long time. It has the appearance of abandonment to him and onsequently he feels free to use the area. A chance at a woods ob every twenty years has no attraction in planning a way of fe. Shorter cutting cycles where feasible, planting, timber-stand nd improvement work, marketing of special products, prompt alvage work, seed collection, renewal of boundaries, all indicate

use of the area and in addition offer opportunities for frequen employment as well as demonstrations of good forestry practice. Incidentally, our handling of part-time work possibilities merit careful consideration and planning. The worker is entitled t know the probable duration and extent of his employment. He ha to live. If only part-time work is available, that time should b so arranged that it interferes as little as possible with his princ pal occupation. If, for example, he is normally a farmer and w work him through the planting season and he misses a cro then we have probably contributed another family to the loca relief load during periods when we have no work for him.

Now, the problem of the young forester: How can he appea businesslike without giving the impression of officiousness? Ho can he take time to explain forest objectives and policy withou creating an impression of idleness? How does he learn of th promises and concessions granted by his predecessors and super iors without incurring official wrath or being regarded as nosy How does he go about learning the attitude of the rural neighbo toward the outfit he represents is important to the organizatio and how can he be made to realize that his actions definitely in fluence that attitude?

With a few exceptions, the attitude and approach of the em ployee reflects quite accurately company policy and attitude o superiors; with almost no exception the reaction of the public t any organization is based on impressions made by the employee with whom they come in contact. The foreman, the timber an wood buyer, the trespass man, the pay clerk, and to an increa ing extent the forester are the windows through which the rura neighbor sees the company. While policy must come from to down, one employee, in his dealings with the public, can, by bein officious, overbearing, grasping, unfair in his dealings, complete negate that policy. If this be true then special concessions, do nations to rural community projects, publicity campaigns, barb cues, and public relations experts, while sometimes useful are n in themselves the solution to the problem. Respect and neighbor support cannot be purchased. It can only be earned.

ATTITUDE MUST BE RIGHT

Perhaps then, the following steps are in order: First, th company attitude must be right. Good public relations must b desired. The company must want the cooperation and suppo of the rural neighbor. This fact should be stressed as part of com pany policy in employing the new forester and others who w contact the public. As a corollary, company policy should b reviewed from the standpoint of public relations. Especial should new programs, new woods activities, be analyzed fro this standpoint. In the job planning stage setting up the progra of explaining the new activity to the public should be just a important a step as any other part of the plan.

Second, the forester must know company objectives and poli and some of the reasons behind them. If he must perform h work on the basis of orders alone he is working in a vacuum. H will make mistakes in interpretation and application. His acti

ities will be misconstrued. It must also be recognized that it takes time to do a good public relations job and that perhaps a few hours spent in getting a message across to the public is more productive in the long run than the same amount of time spent supervising the crew.

Third, the forester must be given the tools with which to do the job. The most important of these tools is the freedom to do a fair and honest job in his dealings with his neighbors. This includes an adequate knowledge of wage scales, stumpage rates, methods of payment, contact requirements, etc., that enable him to be accurate and prompt in his dealings. It also includes explicit instructions as to honesty and fairness in his business transactions. Underestimating, underscaling, unreasonable docking should not be tolerated. He should not be allowed to capitalize unfairly on the neighbor's lack of technical forestry knowledge. At the same time he should understand that there is nothing to be gained by overscaling, overestimating, overpaying and similar practices; that such practices buy contempt rather than support.

Fourth, the forester's public relations activities should be subject to review and inspection, just as is his job performance on other activities. Foresters are human. They place effort on the activities on which there is the greatest pressure. They like to be able to measure accomplishments. Unfortunately the results of a good public relations program are hard to measure and they come about slowly. If emphasis is not placed on the program it is apt to be slighted.

It goes without saying that careful selection of the employee in the first place is an essential. It is difficult in a brief employment interview to form a complete picture of a man's ability to deal with others. Some clues may be found, however, in his college activities, his work experience, and his background.

Changes in public attitude toward large ownerships cannot be expected overnight. Such changes can come about, however, through conscientiously applied programs based on the principles of old-fashioned neighborliness and fair business dealings. More foresters in the woods with closer contact with the people and with authority to handle more and more of the decision on a local basis, as they develop the judgment and capacity to make such decisions, is part of the solution.

As the forester assumes the management of the area entrusted to him, becomes the representative of the company to the people, and makes a place in community life, then part of the fear and distrust of bigness and "foreign" ownership is lifted. When management is intensified and the forester's area of supervision is reduced in size from a small empire to an area of the size that rural people can comprehend (and the forester can manage intensively) this effect will be more pronounced. It is probably too much to expect that the rural neighbor will ever speak with pride of the company as "our company", but it is within the realm of possibility that he will someday think of the forester as a neighbor and of the forest and the resources it represents as an important part of his community.

INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproduction. Please therefore submit well-drawn tracings instead of prints.

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 18 Number 4

FIRE CONTROL NOTES

A Quarterly Periodical Devoted to the

TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

FIRE CONTROL NOTES is issued by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (September 15, 1955).

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Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1957

CONTENTS

RELATIONSHIP OF WEATHER FACTORS TO RATE OF SPREAD OF THE ROBIE CREEK FIRE[1]

R. T. SMALL[2]

Weather Bureau, U. S. Department of Commerce

The Robie Creek Fire in Boise National Forest, Idaho, September 5-9, 1955, is described, and concurrent weather conditions are analyzed. The fire exhibits four different types of behavior during the 5 days. On four of the days, the behavior follows patterns previously recognized as being usually associated with the prevailing weather conditions. The exceptions occur on the third day, which is meteorologically similar to the second day but exhibits a different fire behavior. Some implications that this study has for forecasting and research are pointed out.

Many observations have been made regarding the cause of forest and range fire spread and a number of well-qualified men have made investigations and contributed valuable reports and technical papers on this complex subject. There is general agreement that weather is the most important variable in fire spread, and that the conditions which lead to "blowups" are very complex and difficult to predict.

This paper consists of a report of the weather conditions which existed during the Robie Creek Fire in the Boise National Forest, Idaho, September 5-9, 1955, and an analysis of the relationship of those conditions to the fire behavior.

There are several reasons why this fire adapts itself to an analysis of this type: (1) The fire occurred only 10 to 15 airline miles northeast of the Boise Weather Bureau Airport Station where regular surface and upper air observations are made. (2) The fire area was bracketed by two fire-weather stations, Shafer Butte Lookout, six miles north of Robie Creek at an elevation of 7,590 feet, and Idaho City Ranger Station some 12 miles northeast of the fire, at an elevation of 3,950 feet, in the main Mores Creek drainage. (3) The fire went through four different types of behavior-day: a blowup, a long run, a potentially critical but quiet day, and a quiet day.

[1] An article of this title appeared in its entirety in the January 1957 Monthly Weather Review. A somewhat shortened version is published here through the courtesy of the author and the Weather Bureau.

[2] Our thanks to George M. Byram and Charles C. Buck of the U. S. Forest Service and to DeVer Colson of the U. S. Weather Bureau for their reviews and comments on the first draft of this paper. Our thanks also to the staff of the Boise National Forest for their patience in answering questions and supplying data.

DESCRIPTION OF THE FIRE

The Robie Creek Fire in the Boise National Forest started in the early afternoon of Labor Day, September 5, 1955. It was a hot, dry day; the 45th day since there was measurable precipitation in that area and the 21st consecutive day with the maximum temperature above normal. The maximum temperature at nearby Idaho City Ranger Station that day was 101° F. and the relative humidity was 6 percent resulting in a very high fire danger (Burning Index of 72 on the Forest Service Model 8 Meter).

The fire apparently started on the east side of the Boise Ridge and at a point on a minor slope exposed to the southeast. The point of ignition was in well-cured grass in a light stand of chokeberry brush. Fuel in the general area consisted mostly of dry grass, several kinds of brush, and second growth ponderosa pine. The fire started at an elevation of about 5,000 feet, but eventually spread over an elevation range from 4,000 to 5,500 feet. Although winds were light and variable, the other factors were very conducive to fire spread. Within 2 hours of the time that fire began there were 15 to 20 people from the nearby Karney Lakes Resort, four smokejumpers, and a crew of 20 trained fire fighters at the scene, but the rate of spread was so great that the fire fighters had to retreat from the fire area.

The fire started on Monday, September 5, and was brought under control on Friday, September 9. Of the 5 days, major runs or "blowups" occurred on 3 days: Monday, Tuesday, and Thursday. On Wednesday there were minor flareups, but no sustained run occurred. There was very little spread on Friday as established lines were widened and mopup commenced (fig. 1).

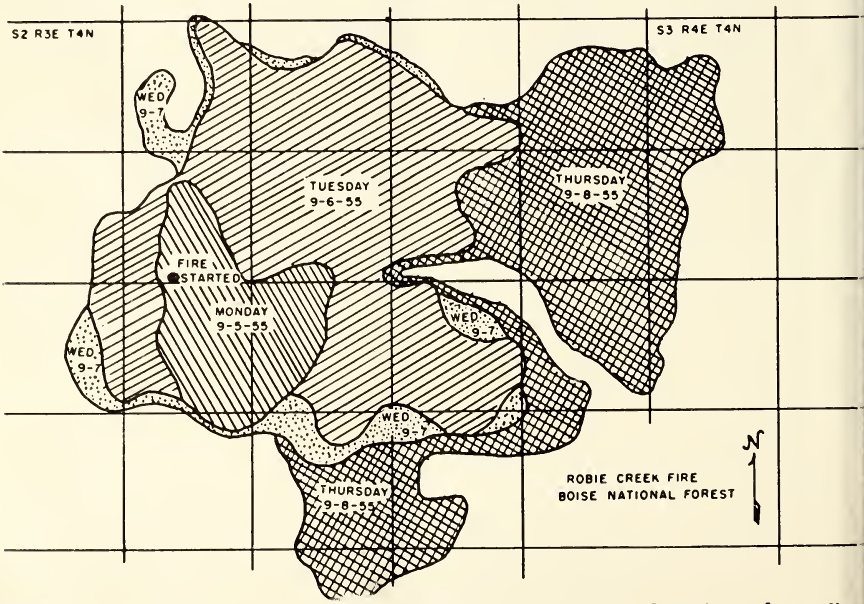

FIGURE 1.—Total area of the Robie Creek Fire showing location where fire started on Monday, September 5, 1955, and its spread on succeeding days. Grid interval equals 1 mile.

During the 5 days the fire spread over 8,310 acres of private and national-forest land. At the peak of the attack over 700 men were employed and total suppression costs were in excess of $100,000.

WEATHER CONDITIONS

In the attempt to determine which weather parameters had the most influence on the fire behavior during the 5-day period, comparisons were made of the various weather data.

The upper air measurements give the values of temperature and humidity at different heights. The decrease in temperature with altitude is called the lapse rate. When this value becomes 5½° F. per 1,000 feet the lapse rate is known as the dry adiabatic lapse rate. With lapse rates considerably less than dry adiabatic, the atmosphere is more stable. Where the lapse rate approaches or is greater than the dry adiabatic rate the air becomes unstable and upward motion is greatly increased.

On the assumption that stability would be an important factor, a comparison was made of the twice-daily Boise radiosonde observations (fig. 2). The lapse rate was very nearly dry adiabatic on Monday, Tuesday, and Wednesday and only more stable on Thursday and Friday.

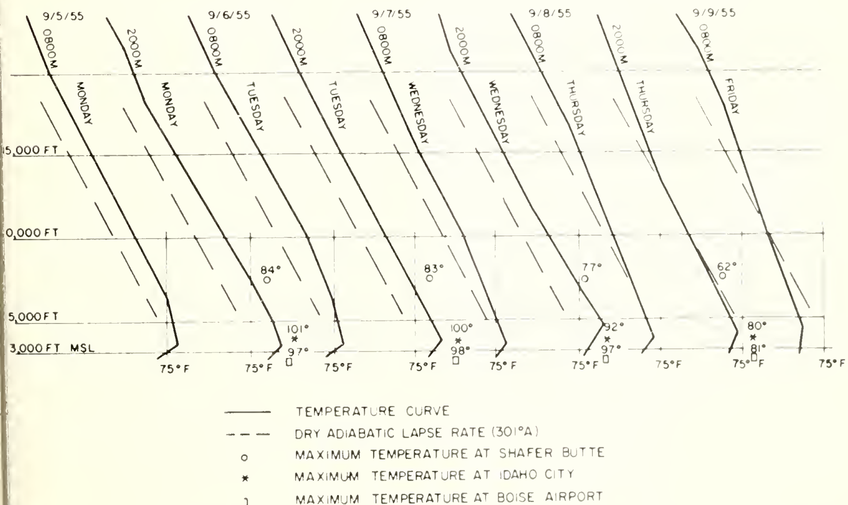

FIGURE 2.—Radiosonde temperature observations at Weather Bureau Airport Station, Boise, Idaho, during period of Robie Creek Fire. Daily maximum temperatures for Shafer Butte Lookout, Idaho City Ranger Station, and Boise Airport are plotted at their relative elevations.

Plotting the maximum surface temperatures at Shafer Butte, Idaho City, and Boise WBAS on the soundings show that superadiabatic lapse rates existed on Monday and Tuesday near the surface, but the layer near the surface was more stable on Wednesday and Thursday.

The surface conditions as shown in table 1 reveal that the weather was hot and dry all 5 days, but that there was a definite cooling on Thursday and Friday.

The wind speed profiles for the 0800 MST and 1400 MST Boise winds aloft observations are shown in figure 3. The wind speeds above 7,000 ft. m. s. l. increased gradually during the first 4 days of the fire and then slacked off again at the end of the week.

TABLE 1.—*The maximum temperature and 1600 MST*[1] *relative humidity for the 5 days of the Robie Creek Fire, Boise National Forest, Idaho, September 5-9, 1955*

Day	Boise Weather Bureau Airport Station		Idaho City Ranger Station		Shafer Butte	
	Maximum temperature	Relative humidity	Maximum temperature	Relative humidity	Maximum temperature	Relative humidity
	°F.	*Percent*	*°F.*	*Percent*	*°F.*	*Percent*
Monday	97	24	101	6	84	12
Tuesday	98	23	100	12	83	14
Wednesday	97	17	92	12	77	14
Thursday	81	27	80	19	62	34
Friday	80	30	81	25	62	40

[1] MST is mountain standard time.

FIRE BEHAVIOR

The fire behavior on Monday was very similar to that of Tuesday and most of the weather data were strikingly similar on those 2 days, except for minor changes in the winds aloft patterns.

Monday and Tuesday both had some of the characteristics associated with a blowup pattern; i. e., steep lapse rates, high temperatures, low humidity, dry fuel, and relatively light winds aloft. On both Monday and Tuesday the major spread occurred in the middle and late afternoon and was accompanied by a nearly vertical smoke column which was topped by a well-developed cumulus cloud. Both Monday night and Tuesday night the smoke filled the surrounding valleys and remained low until upslope motion commenced at 1000 MST on Tuesday and 1100 MST Wednesday.

On Wednesday the fire spread over only about 500 additional acres compared to over 3,000 acres on Tuesday. However, the temperature lapse rate was almost as steep as on the previous 2 days and the minimum relative humidity at Idaho City and Shafer Butte was the same as on Tuesday. There were minor changes in maximum temperature with a drop of 6° at Shafer Butte and 8° at Idaho City. Winds aloft were weaker at low elevations and stronger at high elevations as shown by the wind speed profiles. On Wednesday there was no towering cloud-capped smoke column, only small areas of billowing smoke during the afternoon. In contrast to the previous nights the fire continued to spread during the night, especially near the ridgetops, and there was very little smoke hanging in the valleys Thursday morning.

On Thursday cooler air was obviously moving into the fire area with moderate westerly winds across the Boise Ridge and down onto the fire. In the early morning the fire was moving rapidly up the slopes exposed to the west, and throughout the morning and afternoon the fire continued to spread in an easterly direction. Maximum temperatures were down about 20° from Tuesday and minimum relative humidity was up 10 to 20 percent. Although the fire covered nearly as great an area on this day as on Tuesday the behavior was different. The wind was relatively consistent in both speed and direction and the fire moved from west to east, up slope and down. The forest officials described it as more of a steady "push" than a blowup. The smoke column leaned to the east and although small cumulus tops appeared frequently they disappeared almost as quickly as they formed.

On Friday winds were light and variable, temperatures were about the same as on Thursday, and the relative humidity was higher by 5 to 10 percent. In the afternoon a few minor dust whirls were visible in the ashes and smoke stumps, but at no time was there a serious flareup or threat to the firelines. By this time the suppression attack was organized and lines were well established and manned.

DISCUSSION

Arnold and Buck[3] have listed five atmospheric situations under which fire blowups may occur:

1. Fire burning under a weak inversion.
2. Fire burning in hot air beneath a cool air mass.
3. Combustible gases from a fire accumulating near the ground.
4. Fire exposed to a steady-flow convection wind.
5. Fire burning near a cell of vertical air circulation.

The rapid spread on Monday and Tuesday corresponded to situation 5, and the conditions on Thursday seemed to fit situation 4. On Monday and Tuesday there appeared to be a "chimney effect" reaching to an estimated 25,000 to 30,000 feet which induced a strong draft at the base of the column.

Byram[4] states that for the greatest blowup potential the wind should reach a maximum within the first 1,000 feet above the fire and then decrease in speed with elevation for the next several thousand feet. He refers to this point of maximum wind speed immediately above the fire as the "jet point" and states that the wind speed near the jet point for most dangerous fires will be 18 to 24 m. p. h. for light to medium fuels. Byram has classified the wind speed profiles into four main types, each with two or more subtypes (fig. 3).

In comparing the wind speed profiles of the 1400 MST Boise winds aloft reports for the 5 days of this discussion we find that the profile for Monday resembles Byram's Type 1-a except for wind speed. The wind blowing upslope tended to offset this low velocity.

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[3] Arnold, R. Keith, and Buck, Charles C. *Blow-Up Fires—Silviculture or a Weather Problem?* Jour. Forestry 52: 408-411. 1954.

[4] Byram, George M. *Atmospheric Conditions Related to Blow-Up Fires.* U. S. Forest Serv. Southeast. Forest Expt. Sta., Sta. Paper 35. 1954.

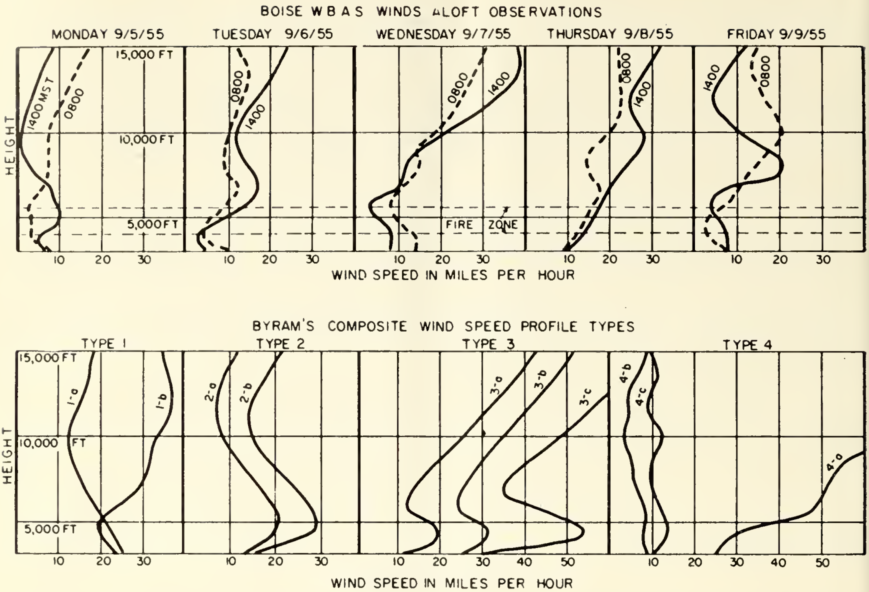


FIGURE 3.—Daily winds aloft observations taken at Weather Bureau Airport Station, Boise, during period of Robie Creek Fire (upper graphs) compared with Byram's wind speed profile types.

The wind speed profile at 1400 MST on Tuesday for Boise closely resembles Byram's Type 3-a with the jet point just above the fire zone. This type has strong winds at high levels, but with a layer of decreasing speed just above the jet point. Byram says of this particular profile ". . . for a fire near 7,000 feet it resembles the dangerous Type 1-a and it is doubtful if the wind speeds at high levels are strong enough to shear off the convection column." Type 3-a and 3-b may be accompanied by strong whirlwinds and rapid fire spread when jet point winds are 20 m. p. h. or more. The winds at the jet point level at Boise Weather Bureau Airport Station were below Byram's minima, but speeds must have been higher just above the fire. Fire crews reported spotting as much as a quarter of a mile ahead of the fire Tuesday afternoon which would indicate some of the whirlwind activity mentioned by Byram.

On Wednesday the wind speed profile resembles Byram's Type 1-b, except that wind speeds in the fire zone were much below the limits shown. The strong winds above 10,000 feet would tend to prevent formation of a convection column which might induce strong winds at the surface. Colson[5] states ". . . the convection column will not attain great heights if the wind speed increases too rapidly with height. Too strong a wind speed may cause the column to be broken away from its energy source."

[5] Colson, DeVer. *Meteorological Problems Associated with Mass Fires.* Fire Control Notes 17: 9-11. 1956.

Byram's Type 4-a resembles the wind speed profile and also the fire behavior on Thursday. Regarding Type 4-a Byram states ". . . fires were intense and fast-spreading, but they could not be considered dangerous to experienced crews, nor were there any erratic and unusual aspects to their behavior."

The speed profile at 1400 MST on Friday closely resembles Byram's Type 2-a, but other conditions reduced the fire danger.

The fire behavior on Monday, Tuesday, Thursday, and Friday followed previously recognized patterns usually associated with the prevailing weather variables. However, the meteorological similarity between Tuesday and Wednesday was remarkable while the fire behavior was very different. Following is a comparison of the 2 days:

1. Fuel conditions on Wednesday were essentially the same as on Tuesday with fuel remaining on all sides of the fire. Lines had been established on some of the fire boundary, but the long run the following day indicates that the spread potential was present.

2. Figure 2 indicates that stability was not the prime differentiating factor.

3. When the maximum surface temperatures at Idaho City, Shafer Butte, and Boise were plotted on the tephigram with the Boise radiosonde observations (fig. 2) it appeared that there must have been a superadiabatic lapse rate near the surface at Idaho City and Shafer Butte on Monday and Tuesday which was not nearly so pronounced on Wednesday. This superheating effect was at a maximum on Monday and Tuesday, was at a minimum on Wednesday, and gradually increased again on Thursday and Friday.

4. Minimum relative humidity was the same both days.

5. Maximum temperatures were the same at Boise and 5° to 8° lower at Idaho City and Shafer Butte on Wednesday, but that change in itself hardly seems great enough to be critical.

6. The winds aloft at Boise Weather Bureau Airport Station show minor differences in direction on the 2 days, but wind speed profiles (fig. 3) varied considerably. Byram's wind speed profile types are different for the 2 days and they offer a possible explanation for the variation in fire behavior between the 2 days.

CONCLUSIONS

The principal objective in an analysis of this type is to develop means of improving forecast and warning techniques. Byram's wind speed profiles have considerable merit, as the evidence has shown, but, from a forecaster's standpoint, it would be difficult to separate the blowup days from the quiet days on the basis of projected 0800 MST wind speed profiles. This is a field in which further study seems warranted.

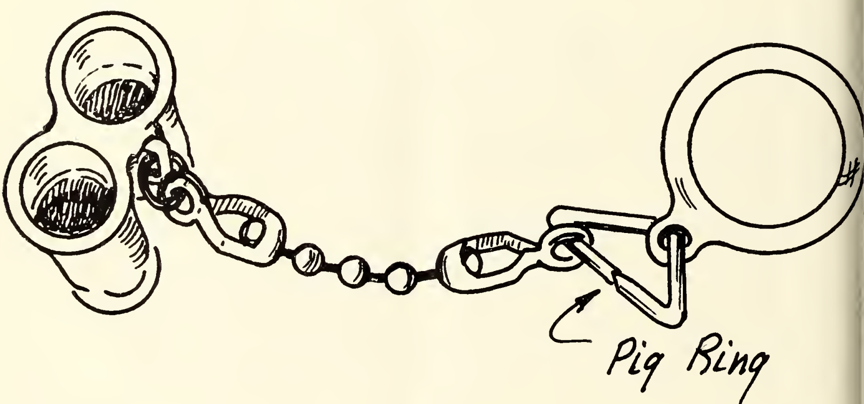
This study indicates that the forecasters on large fires should consider carefully the wind speed profiles and surface temperature distribution as well as temperature lapse rates, surface weather charts, and other observational material. If it were possible to

dispatch a mobile radiosonde observational unit to large fires the information gained would be very valuable to the forecaster in predicting fire behavior. The cost of constructing and operating a mobile radiosonde unit would be considerable, but in view of the terrific property losses and suppression costs on large fires, such a unit would be justified. Pilot balloon observations would be impractical because of visibility restrictions, and only very rarely does a large fire occur close enough to an upper air observational station to make the data representative of conditions over the fire.

☆ ☆ ☆

Pig Rings For Fastening Nozzles To Backpack Cans

Indian backpack can replacement nozzles (part number 235) come equipped with a swivel chain ending in a metal loop. The pump (part number F-9) to which it is to be attached has a washer at the end. This washer extends on one side where it is pierced with a hole where the nozzle swivel chain is to be fastened. Twine, string, or wire are all unsatisfactory for joining the loop at the end of the swivel chain through the hole in the washer on the pump.



A #1 pig ring makes a very secure, stout fastening which can be easily installed with widemouthed pliers. The beveled edges of the ring come together for a very tight fit. The joint may be heated and sealed with solder for a stronger, smooth joint.

The cost is very low and the rings are readily available. One hundred rings sell for twenty cents.—Eldon Campen, *Farm Forester, Division of Forestry, Illinois Department of Conservation.*

STANDARD FIRE FIGHTING ORDERS

1. Keep informed on FIRE WEATHER conditions and forecasts.
2. Know what your FIRE is DOING at all times—observe personally, use scouts.
3. Base all actions on current and expected BEHAVIOR of FIRE.
4. Have ESCAPE ROUTES for everyone and make them known.
5. Post a LOOKOUT when there is possible danger.
6. Be ALERT, keep CALM, THINK clearly, ACT decisively.
7. Maintain prompt COMMUNICATION with your men, your boss, and adjoining forces.
8. Give clear INSTRUCTIONS and be sure they are understood.
9. Maintain CONTROL of your men at all times.
0. Fight fire aggressively but provide for SAFETY first.

Every Forest Service employee who will have fire fighting duties will learn these orders and follow each order when it applies to his assignment.

(s) R. E. McArdle
Chief, Forest Service

une 28, 1957

HELICOPTER MESSAGE OR CARGO DROP-AND-PICKUP KIT

JAMES MURPHY[1]

A helicopter drop-and-pickup unit has solved many of the communication problems arising on fires and other projects, particularly where the use of radio is limited.

THE MESSAGE UNIT

Any type of conventional message tube may be used (fig. 1). Surplus Army plastic message cylinders were used for the origi-

[1] Cooperator, California Forest and Range Experiment Station, working under cooperative agreement with Utah State University. This report is based upon work which was conducted by the writer while employed as Air Officer, Angeles National Forest, Region 5, U. S. Forest Service.

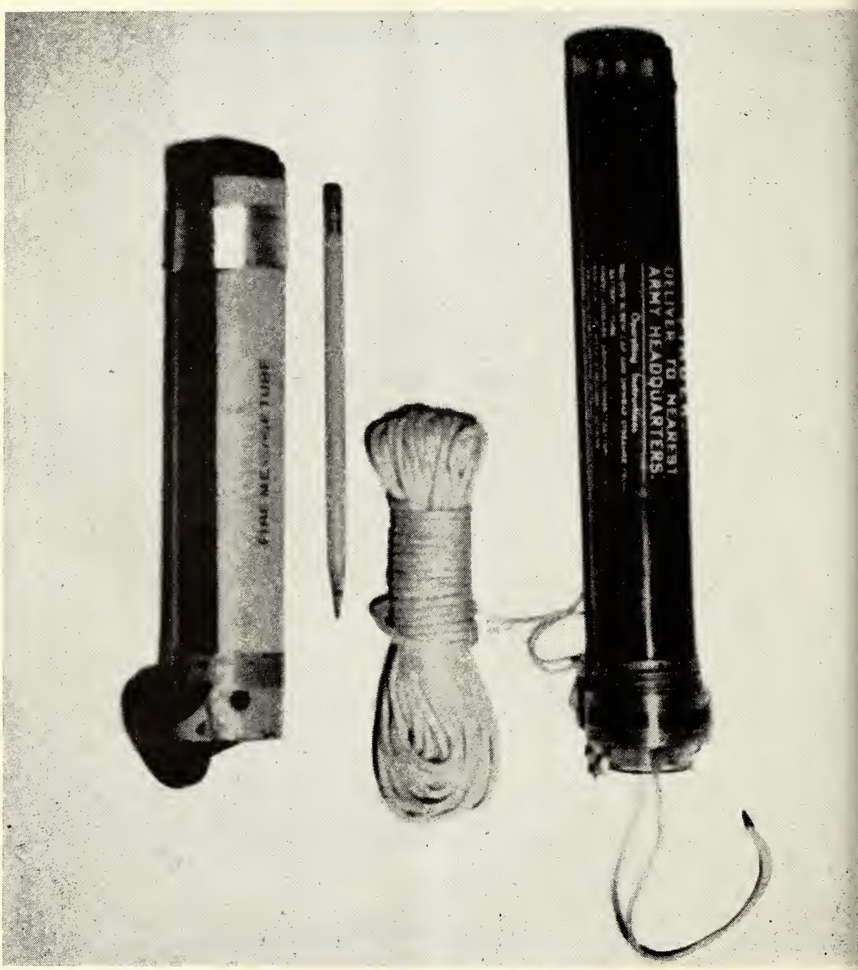


FIGURE 1.—Two types of message units. *Left:* U. S. Army message cylinder with holes drilled in cap for pickup cord. *Right:* Homemade cardboard tube with elastic band to hold caps in place. Nylon cord, pencil, and instruction sheet are enclosed in message tube.

nal tests. Holes were drilled in the plastic caps through which a nylon cord could be passed when preparing for the pickup. A less expensive and simpler message tube was developed later in the season from a 1½-inch diameter cardboard tube cut in 9-inch lengths. One-half inch elastic garter bands were looped lengthwise around the entire tube, attached to cardboard caps, and immobilized with acetate tape at each end of the tube. The elastic allows the caps to be stretched from the tube far enough to insert or remove the message. A long yellow streamer makes the unit visible during the air drop. Enclosed in the message tube are a pencil, sheet of instructions, and 35-foot length of nylon cord.

THE PICKUP UNIT

The pickup unit remains with the ship at all times. It consists of a hand reel, much the same as a fishing dropline hand reel, and a heavy nylon cord (parachute shroud cord) with a weight attached. The weight is cast from any light metal alloy and should weigh a minimum of 8 ounces for maximum control. It it 3½-inches long and tapers from the rounded base, 1½-inches in diameter, to ¾-inch at the top. Three triangular projections extend the top surface of the weight ⅜-inch, forming three grooves between them. A ¼-inch hole extends lengthwise through the weight for cord attachment. For safety reasons, the weight should be painted high-visibility yellow (fig. 2).

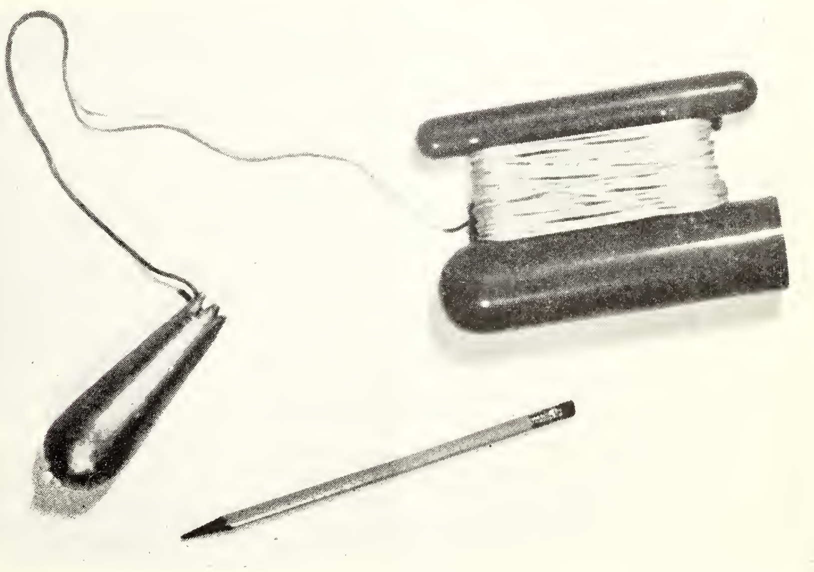


FIGURE 2.—Pickup unit consists of hand reel, cord, and weight. Note projections and grooves on top of weight to catch cord to which message tube is attached.

HOW IT IS USED[2]

1. The message tube is dropped to the ground party with message and pickup instruction sheet enclosed. Care must be taken in dropping tube so that men on the ground are not endangered. If a return message pickup is desired, the yellow streamer is waved by the man on the ground.

2. The nylon cord is removed from the message tube and unwrapped. It is threaded through the holes in the message tube, and the ends are tied together. The result will be a continuous loop of cord with the tube attached.

3. The cord is suspended loosely 6 feet above the ground by two men standing 15 feet apart. The remainder of the cord loop and the message tube are allowed to trail on the ground. Sticks may be substituted to support the cord if assistance is not available (fig. 3).

4. The helicopter reduces speed to about 20 miles per hour and flies as low over the area as is safe. The weight and cord are paid

[2]The techniques described here should not be tried unless the crew has been properly instructed in the safety practices required. If, for example, the pickup cord is held too tightly, the message unit may be flipped into the 'copter's control cables or its tail rotor.

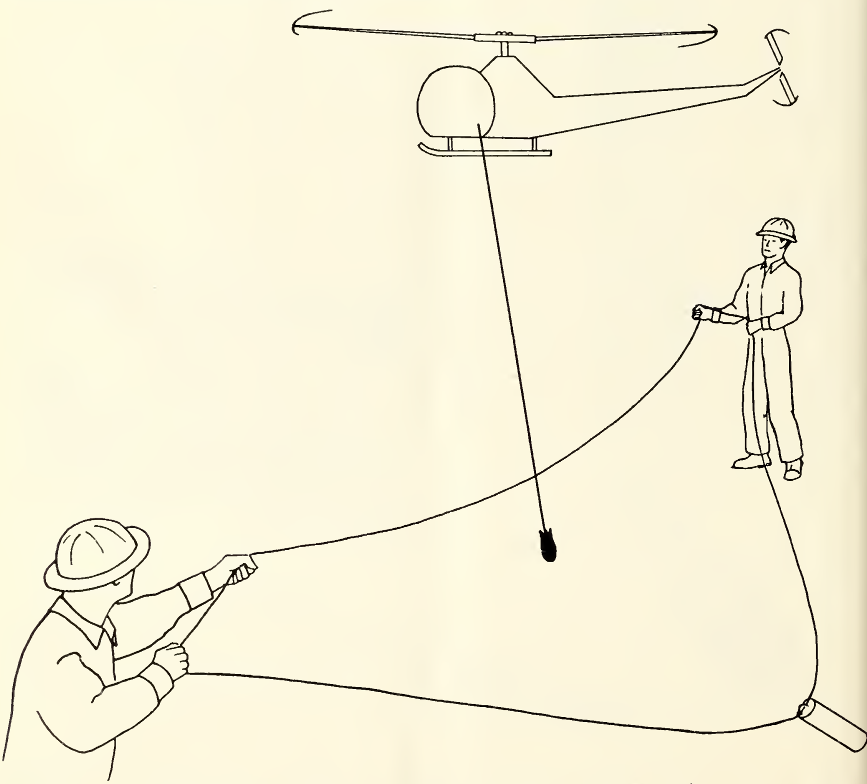


FIGURE 3.—Helicopter, moving at slow forward speed, flies over pickup area. Grooved weight, suspended from the ship, contacts the cord with attached message tube, and the air snatch is completed.

out over the front horizontal tube of the skid assembly until the weight is near the ground. The horizontal tube, present on the Hiller and the Bell 47-G, acts as a guide and furnishes better control over the weight. The weight is lowered until it hooks the suspended cord. The cord is reeled into the helicopter, and the message pickup is complete.

The same procedure is used when a cargo pickup is necessary. The cargo is packed in a knapsack or tied securely in a bundle and substituted for the message tube during the pickup procedure. All tests were made with weights less than 60 pounds, and further experimentation is necessary before cargo pickup in excess of 60 pounds can be attempted.

The drop-and-pickup device and procedure have been tested on many occasions. It takes little time and is simply executed. The reduced speed of the helicopter and the ability of the man in the ship to guide the weight reduce the chance of the weight striking the men on the ground. There are no hooks involved, and therefore no danger of "hanging-up" the weight on brush and other ground objects while performing the pickup.

COMBINATION PUMP TRUCK AND TRACTOR TRANSPORT

LOREN A. TUCKER
Supervisor, Division of Fire Control, Washington Department of Natural Resources

To bring more flexibility and utility into tractor transport for fire fighting, the Fire Control Division of the Department of Natural Resources in Washington has designed a rig for transporting small D-4 class tractors equipped with dozers. An especially designed dump truck provides pulling power. It has a two-speed rear axle with an 18,000-pound carrying capacity, heavy duty front springs with a 5,500-pound carrying capacity, and a 360-cubic inch displacement engine ordered special to haul the extra load. A 980-gallon flat tank slipon unit is designed as a pumping unit. This unit is divided into two compartments so that the truck can carry 200 gallons of water at all times, even while it is pulling the tractor transport. The truck is equipped with a heavy duty hitch to haul a lowboy trailer, which is used as the tractor transport (fig. 1). The first lowboy was built in the Department shops, but it was later found that they could be purchased direct from a trailer construction company as cheaply as our shop could build them. The trailer has a 24,000-pound gross vehicular weight.

FIGURE 1.—Combination pump truck and tractor transport.

Contrary to the old conventional flat-bed transport, which was of very little value once the tractor reached the fire, this unit transports the tractor to the fire and the truck is disconnected and used as a pump truck for initial attack and mopup purposes until time to transport the tractor back home again.

For road maintenance projects, this has proved to be an ideal unit also, as the dump truck takes the tractor right along with it. The two can work together on fills and culverts and it is not necessary to have a driver for the tractor transport in addition to the regular dump truck driver.

Detailed specifications can be furnished by the Department to those who are interested.

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Smokey At Lake Ouachita

Smokies, by the thousands, ride the waves of Arkansas' Lake Ouachita in the continuing effort to keep the fire prevention message before the two million visitors seeking recreation on and around this new 40,100-acre lake administered by the U. S. Engineers in the heart of the Ouachita National Forest. The concessionnaires at the fishing villages and boat rental landings were requested to let us put Smokey bumper strips—Prevent Woods Fires—in the bow of all their boats. All of the operators enthusiastically offered their boats to transport Smokey as a constant reminder against forest fires. With Smokey in the boats, signing the islands came next. The islands are signed, along with their identification number, with the standard 44x16 fire prevention poster mounted in a new frame. The Corps of Engineers has fifteen recreation areas on Lake Ouachita, and in these we are using a small standard Smokey poster, mounted in a neat wooden frame with a small hangover to keep his nose in the shade. Fifty of the islands are posted with the big 44x16 signs, and 100 of the smaller Smokey frames adorn the recreation areas. The lodges and concessions are displaying the easel type Smokey.

This fire prevention project, aimed at the multitude of fishermen at Lake Ouachita, was a cooperative arrangement between the concessionnaires, Corps of Engineers, and the Jessieville and Womble Ranger Districts of the Ouachita National Forest. All made some contribution in making frames, mounting posters, and placing them in boats, on islands and peninsulas, and among the recreation areas and lodges of the fishing villages.—W. L. LANE, *District Ranger, Ouachita National Forest.*

HONEYCOMB PAPER FOR PROTECTION OF AIR CARGO

W. C. Wood
Equipment Specialist, Region 1, U. S. Forest Service

The Missoula Aerial Equipment Development Center has recently begun a preliminary study of the value of honeycomb paper for absorbing impact shock on air cargo. While considerably more investigative work remains to be done, it was felt that the information brought out to date should be passed on for the benefit of those involved in aerial delivery programs. Undoubtedly, field use of this new material will result in the development of new methods and techniques.

Briefly, honeycomb paper is a direct imitation of the honeybee's architectural ingenuity. Strips of ordinary kraft paper are formed into cellular sections similar to those found in beehives. These cellular sections are sandwiched (glued on edge) between flat sheets of kraft paper. When subjected to impact loads, the paper cells crush and absorb the energy of the impact. The honeycomb paper is available in several thicknesses with a variety of cell sizes and kraft paper weights. The smaller cells and heavier paper, of course, yield at higher impact forces and thus provide more energy absorption. For some cargo the use of honeycomb pallets will provide as much as 400 percent increased protection against damage.

In drop tower tests, it was shown that lightweight 5-gallon tins of water would burst upon impact when dropped unprotected on soft ground from a height of 9 feet. With 3-inch honeycomb pallets, these cans could be dropped from 18 feet without bursting. The increase in velocity as a result of falling this greater distance resulted in approximately four times more impact force.

Honeycomb is adaptable to Forest Service cargoing techniques. It is particularly well suited for use in palleting of air cargo. Water cans may be banded singly or doubled and protected by honeycomb (figs. 1 and 2). For most purposes, it is better to ex-

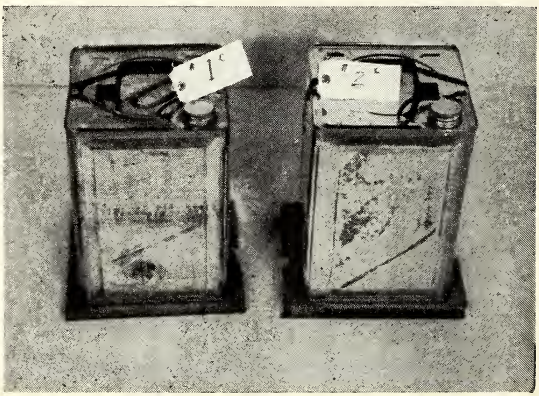

Figure 1.—Single 5-gallon disposable water cans with metal-strap cargo method and with honeycomb pallets, ½ inch and 1 inch thick.

FIGURE 2.—Double can cargo method. Note that board is used to prevent metal band from crushing cans. Small wooden blocks hold cargo handle in place. Honeycomb is 1½ and 2 inches.

tend the pallet edges approximately an inch beyond the corners of containers. An equipment development proposal to investigate the application of honeycomb to other standard cargo items (tools, etc.) has been approved for fiscal year 1958. One optimistic viewpoint is that with proper use of honeycomb padding, certain durable cargo items might be delivered free fall without damage.

Honeycomb pallets are superior to plywood or other wooden pallets. Honeycomb may be easily cut with a handsaw and is extremely lightweight. It is sold in board-foot quantities and is less expensive than plywood. Recent price lists show honeycomb to cost about 6 cents per board-foot.

Air drop tests using 12-foot diameter parachutes showed that more than twice as much water can be dropped without damage when honeycomb pallets are used (fig. 3). In some cases water cans burst upon impact when the honeycomb pallet failed to crush and absorb the energy of the impact. Pallets made from lighter

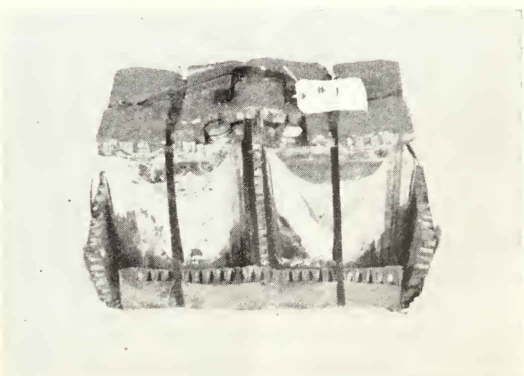

FIGURE 3.—Ninety pounds of water dropped on a 12-foot parachute. Note deformation of cans without leakage. Honeycomb at top and sides is unnecessary.

paper and with larger cells would, in this case, provide more protection. A good deal of experimenting will be necessary in determining the correct weights, sizes, and thicknesses needed to provide maximum and economical protection for the various air cargo items used in fire control work.

As with any kraft paper the honeycomb is weakened by moisture. Reasonable precaution against wetting should be taken. Resin-impregnated honeycomb (water resistant) is available, but at higher cost. Honeycomb sheets should be ordered expanded and faced on two sides. For most water cargo in standard 5-gallon cans, we suggest the 1-inch thickness until additional information is obtained. This is described as 99(0) ¾ EDF Caliper 1 inch. For added protection, additional sheets may be used. Honeycomb paper may be ordered from leading paper fabricators.

AIRBORNE BUCKET BRIGADE[1]

Bush fire fighting planes in Ontario may be soon equipped with water tanks that can be filled while the aircraft skims over a lake. One Department of Lands & Forests plane, an Otter stationed at Sault Ste. Marie has been fitted with a tank on each float (fig. 1). It can take on 180 gallons of water in 18 seconds—without stopping. This is accomplished as the aircraft skims along the surface of a lake dragging a refill pipe on the step of the seaplane float.

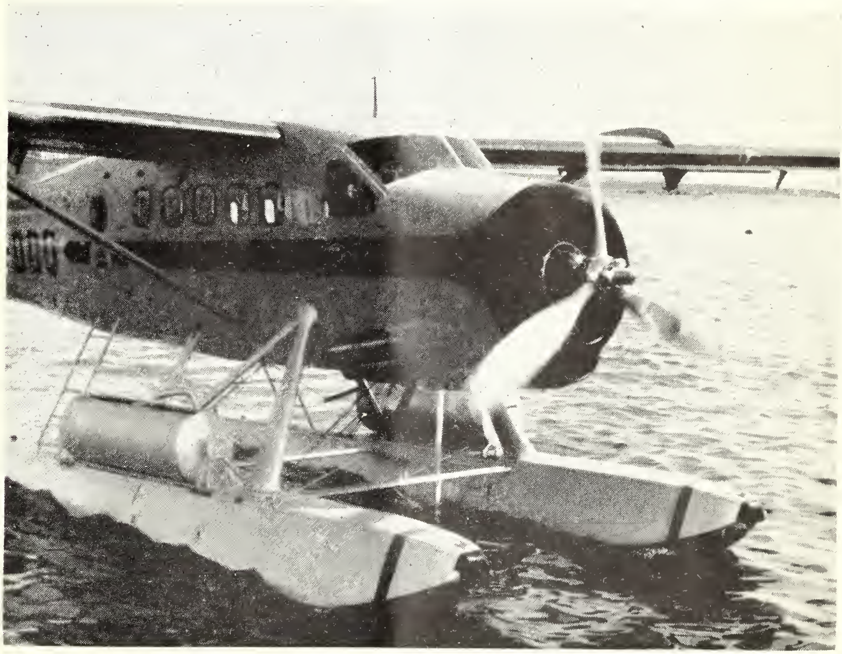

FIGURE 1.—A float-tank-equipped Otter.

While the float tank designed by Lands & Forests engineers is still in the development stage, the Department considers it highly promising (fig. 2). Said District Forester William Cleaverley, "a plane flying in the neighborhood of 100 feet can concentrate a 180-gallon drenching and really saturate the area. Pumps and water-bombs are ineffectual when compared to the new tanks."

[1]Illustrations for this article were furnished by the De Havilland Aircraft of Canada, Ltd., Downsview, Ontario.

FIGURE 2.—Flying low and slow over the fire, the pilot flips the switch, the tanks revolve and open to release their cargo. Baffle plates prevent the water from sloshing.

In earlier experiments the tanks were fitted to the fuselage of the plane, but with tanks thus positioned the plane had to stop to reload. The "on the run" reloading feature of the float-positioned tanks cuts the turn-around time to a fraction. Given a situation where a fire is burning within 2 miles of a lake, a float-tank-equipped Otter could deliver an approximate 1,800-gallon drenching over the fire area within an hour. This would thoroughly drench an area of 2,000 square feet.

Since 1948, Ontario Provincial Air Service Beavers (and later Otters) have been fighting fires in Ontario's woodlands (figs. 3 and 4). OPAS is the Department's air arm and has some 40 Beavers and 5 Otters. The Otter's float tank will be redesigned to fit the smaller Beavers.

A useful piece of fire fighting equipment transported by the Beaver to otherwise inaccessible forest fire locales is the pack tractor which can be taken apart, put in the cabin and quickly reassembled when the destination is reached. Developed jointly by the Research, Air Service, and Forest Protection Division, this small, but highly efficient wheel-track vehicle will carry a 700-pound load up a steep hill at walking speed.

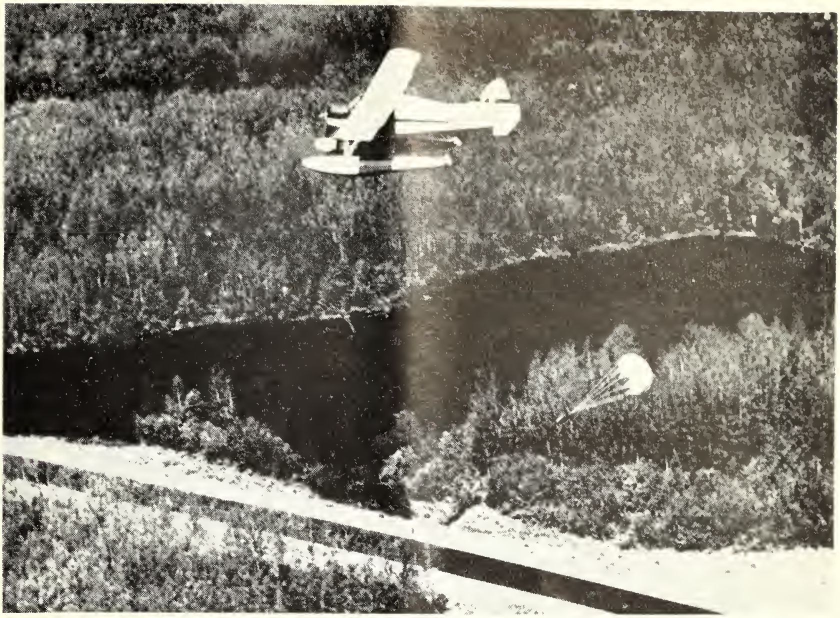

FIGURE 3.—A Beaver drops a portable gas-engined fire pump in a cushioned cannister to a waiting fire crew.

FIGURE 4.—Equipment unloaded from Beaver to dock after successful fire fighting operation.

PRIMACORD TESTED FOR BLASTING FIRELINE

W. G. BANKS and R. H. FENTON
Foresters, Northeastern Forest Experiment Station

Labor for fighting forest fires is not always readily available in the Northeast; so any tool that offers even a remote possibility of reducing fire-control manpower requirements seems worth investigating. Primacord, a type of detonating fuse used in blasting, fell in this category. Primacord was considered as a means of making or helping to make firelines.

Some testing of Primacord as an aid in making firelines was previously conducted by Thomas W. Church, Jr., of Whitney Industries, Inc., in northern New York; and his findings were similar to ours.

Primacord consists of an explosive core of Pentaerythritetetranitrate contained within a waterproof textile or plastic cover. The cord comes in rolls of 500 and 1,000 feet, of various strengths from 40 grains per foot upward. The cost is approximately 3½ cents a foot for 50-grain cord with plain textile cover, and double that for 100-grain cord.

It was recognized that there might be a number of drawbacks to the use of this product. For example: (a) the danger of working with explosives in close proximity to going fires and under the pressures frequently accompanying fire suppression; and (b) the possibility of setting additional fires. However, we decided to carry out some exploratory testing of Primacord to observe in a general way its capabilities and limitations for making or helping to make satisfactory firelines.

Primacord is relatively safe to use and store. According to the manufacturers it cannot be set off by friction, sparks, or any ordinary shock, but must be detonated with a blasting cap attached to it. To check the sensitivity we laid two short pieces within 2 inches of a stretch of cord being detonated. These sections were blown several feet away and the covering was torn, but they were not exploded. One short section was burned without indication of explosion.

Tests were conducted April 15, 1957, at the Virginia Pine-Hardwood Research Center at Beltsville, Md. The two major objectives were:

1. To test the potential of Primacord for making an adequate fireline under various conditions of litter and underbrush.

2. To test the fire-setting hazards of Primacord.

Our tests were made in (1) mature Virginia pine-hardwoods with heavy hardwood litter and patches of low brush; (2) pure Virginia pine 40-50 years old, open, and with considerable underbrush; (3) mature hardwoods, lightly logged, open; and (4) pure Virginia pine about 30 years old, fairly dense and with little underbrush. During the period of testing, the burning index ranged from 35 to 60 on the Southeastern Forest Experiment Station meter type 8.

Only the 50-grain Primacord was available for our tests. For a heavier blast we twisted two 50-grain strands together and assumed that this would give approximately the same results as the 100-grain cord. Both single and double strand were used in all types except the 40-50-year-old pure Virginia pine.

The principal results of our tests were as follows:

1. The firelines were judged to be inadequate to stop a surface fire, or to backfire from without additional widening and deepening. It was estimated that the time required to make a satisfactory line would be reduced no more than 30 percent by using Primacord. The best line made was in a pure Virginia pine stand about 30 years old. This resulted from a double strand of Primacord and probably reduced by 50 percent the time required to make a satisfactory line for backfiring.

2. Double lines, as well as splices and loops of 50-grain Primacord, were exceedingly liable to start fires in hardwood litter (fig. 1). In the course of testing, many fires were set. On one 30-

FIGURE 1.—Primacord at moment of detonation. A noticeable flash of fire occurred, especially when a double strand was used.

foot stretch of double strand, seven fires were started (figs. 2 and 3). On another short stretch of about 8 feet of double-strand Primacord, the whole line seemed to burst into flame.

FIGURE 2.—A double strand of Primacord laid and ready to detonate in a mature Virginia pine-hardwood stand. The litter here is mostly hardwood leaves.

3. No fires were started in pine litter. However, in spite of the burning index, the pine litter would hardly support a fire. If conditions were such that surface fires would spread readily in the pine, then the Primacord might set fires there too. We were unable to determine this possibility while these tests were being made.

4. When suspended on brush only a foot above ground the Primacord was of little value in making a fireline.

On the basis of these limited tests, the authors feel that Primacord has no practical application for fire-control work in the pine and hardwood stands of the coastal plains in the Middle Atlantic States. Nor were we encouraged by the results to continue the tests elsewhere in the Northeast. Of course there may be certain conditions under which this material would be helpful in fireline construction, for example, in the pine flatlands of the deep South, where rather light litter is found on top of sand.

FIGURE 3.—The line made by detonating the Primacord shown in figure 2. Seven fires in 30 feet of line were started by the detonation.

HIT 'EM HARD WHILE THEY'RE SMALL

TOM SMITH and MARK BOESCH
Bitterroot National Forest

This story was written for use in training initial attack forces and inexperienced dispatchers. It is applicable mostly to mountainous timber areas of the West but should be of interest to all forest fire control men.—Ed.

KEEPING AN EYE ON THE WEATHER

It was 0730 on the morning of August 10. The Darby District of the Bitterroot National Forest was ready to begin another busy summer day. Dispatcher Boesch turned to the brush crew foreman, about to leave for the Lick Creek timber sale area with his four-man crew.

"Clarence, we better have hourly checks beginning at 0930. I'll have the weather forecast from the Supervisor's office by then, and we'll have an idea of what's in store for us. If I don't miss my guess, you fellows will be on fires before the day is over."

"Okay," Clarence Lindquist replied. A few minutes later he and his crew pulled away from the ranger station in the carryall after making sure it was fully gassed and ready for a lot more miles than the ten or so that would take them to their brush piling job.

District Ranger Foskette came into the office about that time.

"What's the picture for today, Mark?" he asked his dispatcher.

"The brush crew's on the way to Lick Creek, Red. The East Side trail crew will be working Trail 159 on the way to Coyote Meadows. They should be checking in soon. We should be hearing from the Tin Cup Trail crew any minute, too. I have a hunch we're going to be busy today. Here's the weather picture, based on yesterday's readings."

The dispatcher handed the ranger the sheet that had on it not only the weather readings he had taken at the weather station the evening before, but also the estimated readings for this day. Ranger Foskette studied them carefully.

The dispatcher had predicted for this day of August 10 that the ½-inch fuel sticks would weigh 5; there would be a severity index of 8; humidity of 15 percent; a wind average of 10 m. p. h. during the afternoon, making a burning index of 65. He also predicted lightning for this day.

"Wow!", Foskette exclaimed. "We better pray for rain with that storm."

"Trouble is, these August storms don't give us much rain," Boesch said. "When they do, it's generally spotty. Right now we have dry areas on the district. Rock Creek is one. Hasn't rained up there since July 20, and only a trace then."

"Lucky thing we haven't had any hot storms the past 2 weeks the way this weather's building up," Foskette said. "But we're bound to catch it sooner or later. Well, I've got to check some of the range today. This dry weather isn't doing the grass any good either. I'll take the mobile unit. Call you first from Smitty's, up Rye Creek."

Bad as this weather was, Red Foskette couldn't just let everything else drop and sit tight there at headquarters, waiting for something to happen. That's what he had his dispatcher on the job for. Boesch had been dispatching for 10 years. If he wasn't capable of taking action on a fire bust now, he never would be. And he had good men to aid him. There was the headquarters guard, a man with wide experience who could fill in behind the dispatcher at headquarters, or who could go out and take over a fire. There was also a station fireman, a skilled smokechaser who had seen a lot of fire action. And there was the packer-truckdriver, who could either take a string of mules up the trail to a fire, or could drive a truck load of fire fighters and/or equipment to the end of a road.

The Darby District Ranger was a resource manager of 391,000 acres of forest land. He was as concerned with fire as anyone else, but he had other things to look after too, such as grazing, timber sales, road, trail, and other improvement work. He had skilled, key men to help him with these various duties. The assistant ranger did a lot of the timber work, helping to supervise the cutting by private operators of some ten million board-feet each year. Today the assistant and his helper would be working at headquarters on scale books. But the alternate ranger was up Tin Cup Creek, inspecting the trail reconstruction job that was going on there.

When the two-man East Side trail crew checked into headquarters by radio relay via the Deer Mountain lookout, Boesch gave them the same orders he had given the brush crew foreman. The same was true when the Tin Cup crew checked in.

EQUIPMENT CHECKED AND COOPERATORS ALERTED

Following the radio business Boesch gave orders to his headquarters men to make sure all the station vehicles had been gassed up the night before and now were ready to go. He told them to check all the equipment. Then he mentally checked what they had available. This included two pickup trucks, a Dodge power wagon, and a one-ton stockrack truck. There were 25 smokechaser packs made up, 2 10-man loose tool outfits, 1 Pacific pump with 1,200 feet of hose, 4 handi-talkie radios, 1 jeep pumper unit, and 2 25-man standard fire fighting outfits, the latter sufficient to fully equip 50 men on a fire. Finally, there were 2 chain saws. Soon the dispatcher heard the men warming up both chain saws out in the shop, making sure they were ready to use on a fire. Then they were testing the handi-talkies, calling the lookouts to make sure these vital radios were functioning properly.

It was now 0815. Boesch opened the front door of the office. Beginning to get a little warm.

"Going to be a hot day," he said to his clerk, who was busy typing a timber sale contract.

Boesch went back to the fire desk and opened his dispatcher binder. He turned to the section where the cooperators were listed. These people—farmers, ranchers, dude packers, townsmen, and logging and mill crews—had all been contacted early in June. All were listed there in the binder, along with their experience, capabilities, and the kind of equipment they had to offer. The latter included trucks, jeeps, mules and horses, school busses, chain saws, and even bulldozers. Boesch was personally acquainted with most of these cooperators and could talk to them on a first name basis. Now, he began calling them, seeing who would be available for fire duty that day.

Some of the ranchers in the valley had hay down. Even so, most of them agreed to come to his aid if Boesch needed them badly enough. Most of them were grazing permittees. They had a big stake in this business of stopping fires.

Jack Lykins, a commercial packer on the district, had a full string available, shod and ready to go, with his own truck to haul them wherever they might be needed.

The sawmills had their crews working, and they would spare what men they could in an emergency. They, too, had a stake in this business, since they could not long remain in business without Bitterroot Forest timber.

The two restaurants in the town of Darby were alerted to be prepared to make double lunches for fire fighters. They knew what to put in these lunches—four big sandwiches, fruit, several candy bars, cookies or pastry—enough to do a man all day if necessary.

As Boesch called the various cooperators, individuals, and crews, he made notes on his ready pad on who and what was available and even how to contact them. That was not only for his own use, but for someone who might have to fill in for him here at the desk when the going got heavy.

By the time Boesch was through working on the list of fire cooperators, it was 0900 and the forest dispatcher, Tom Smith, was calling all five of the Bitterroot districts on the radio.

"Here's the weather forecast," Smith said. "And it's a bad one. Increasing cumulus clouds today, followed by moderate, scattered lightning storms with little or no rain over the Nezperce, Bitterroot, Beaverhead, and Deerlodge forests. Humidity will range from 15 to 25 percent over southern areas. Maximum temperature at 3,000 feet, 90 to 95 degrees. Winds will be light to gentle, but moderate and gusty in vicinity of lightning storms." Smith then suggested that each district review its manpower situation and arrange to have necessary men available for immediate action.

Boesch gave his 10-4 that he had received the forecast okay, then after the other districts had done the same, he got back on the radio again with Smith.

"Tom, in view of that forecast, maybe you'd better alert that boomer crew of yours and have them available. Looks like we'll be needing them."

"Will do," Smith replied. He was proud of this crew of young cooperators he had organized to chase smoke and fight fire. Their ages ran from eighteen to the early twenties—about a dozen young huskies who had been trained through previous smokechasing and fire fighting jobs to do a good job of hitting the trails with fire packs, all of them being in fine physical condition.

"I'll alert Fred Fite, the regional dispatcher," Smith told Boesch. "We'll probably be needing smokejumpers too."

After this radio business with Smith, Boesch called the two Darby lookouts to give them the weather forecast—Deer Mountain, in the Sapphire Range on the east side of the Bitterroot Valley, and Ward Mountain over on the west side in the high, rugged Bitterroot Range. The two lookouts wrote the forecast in their logs. Then Boesch got a weather check with them.

"Scattered cumulus in the southwest," Deer Mountain said.

"Yeah, looks like we're going to get that storm all right," Ward Mountain agreed.

FURTHER PREPARATION FOR THE BUST

The forest dispatcher called Darby. "The patrol plane will take off from the Hamilton airport at 1000," Smith said. "They'll be flying Flight B, down Darby's west side, through the West Fork District, over into Idaho for a look at the Magruder and Salmon River country, back over into the Sula District, over Darby's east side, then both sides of the Stevensville District. Pass the word to the other districts."

As Boesch gave this information to the districts that lay south of him, he also checked with them on the manpower they had available that day. They were accustomed to swapping forces back and forth in the kind of bust that was now shaping up.

It was now 0930.

The crews began checking in via radio. Boesch gave each one the weather forecast and told them to be sure and check in again at 1030.

At 1000 Deer Mountain called. "Those clouds are really building up," he said. "That storm is on the way."

Calling Ward Mountain, Boesch got much the same report. Then he called Smith. "Tom, how are you doing with recruiting your boomer crew?"

"Have six of them standing by here. Can probably get four or five more within an hour or so."

"Better send what you have here for standby," Boesch told Smith.

"Will do," Smith agreed, "one of them has a car. They'll ride up in that. And, Mark, I checked with Fite. He has plenty of jumpers available. In addition there are 100 Blister Rust men available on the St. Joe Forest. Don't hesitate to call on them. I've notified Vern Hamre, who is at Stevensville, of what's shaping up."

"10-4," Boesch said. Hamre was the fire control staff officer.

It is 17 miles from Hamilton to Darby. Those six men would be at the district headquarters within 30 minutes.

Boesch was looking out the front door toward the southwest, seeing the angry-looking cumulo-nimbus himself now, when the boomer crew pulled into the station. About the same time the brush crew was calling from Lick Creek. Boesch stepped over to the radio.

"Bring your crew in, Clarence," Boesch told foreman Lindquist. "We'll be getting lightning soon."

He got the verification of that when he heard one of the West Fork District lookouts calling his headquarters, reporting lightning on the southern edge of that district.

"Not much rain with it, either," he heard the lookout say grimly. "But, it looks like Darby will get the worst of this one."

From then on the radio stayed busy, with Boesch glued to the fire desk. Ranger Foskette called from the Smith ranch, was apprised of the situation, and said he would start back for headquarters at once. The East Side trail crew checked in, and Boesch told them to stay in contact with Deer Mountain for possible fire duty. The Tin Cup crew called and was told to check in again at 1100, and every half hour after that. The patrol plane checked in from over on the west side, one of their routine 15-minute checks, this being a safety factor. The observer gave Boesch their location, then called Smith. Boesch heard the observer tell the forest dispatcher that they would not be able to make their scheduled patrol because of the menacing storm. Smith ordered the observer to keep a watch on the route of the storm and to continue checking in regularly with the district dispatchers.

It was 1100. Deer Mountain called to report that the storm had entered into Darby District and was putting down lightning at the head of Trapper Creek on the west side of the valley.

Boesch now had available at his headquarters station the six-man boomer crew of Smith's, the five-man brush crew, the assistant ranger and his helper, the headquarters guard, the station fireman, and the packer-truckdriver. The storm was now moving along the west side of the district, lightning plastering the head of Trapper Creek, then moving north to hit sections of Chaffin, Tin Cup, and Rock Creek. But, as it neared the deep drainage of Lost Horse Creek, it veered eastward, crossing the wide Bitterroot Valley where it started a barn on fire, killed two cows in a field, then started plastering the forest again in Sleeping Child Creek, from where it moved northeast across the Skalkaho drainage and finally passed out of the district over the head of Gird Creek. All the while the forest patrol plane flew near the storm, watching the areas of hot lightning concentration.

Even before the storm passed out of the district, about half an hour after it first arrived, Deer Mountain was calling in the first fire location.

MEN AND PLANES DISPATCHED

The fire was at the head of Tin Cup Creek, one of the worst areas on the district. Dispatcher Boesch was glad now of having

that crew in Tin Cup. Almost immediately he was able to contact them by radio. He gave Alternate Henderson the fire location, and they agreed that four of the seven trail men had better get started for it. They were all set to go, having fire packs in their camp. With a 3-mile hike ahead of them, they should be able to hit the fire within 2 hours.

Boesch contacted the patrol plane and asked him to swing over the Tin Cup fire. He would be there in about 5 minutes, and after a good look at it would be able to give the dispatcher a better idea of its potentialities. Boesch might have all of that Tin Cup crew on this fire before it was over with. But he couldn't sacrifice too much of his manpower on the first fire.

It was 1130. Ward Mountain now called in. He had a fire over near Bald Top Mountain on the east side of the valley in the Sleeping Child drainage. "Looks bad," he said. "Spreading fast."

He reported the smoke as being white, with a heavy volume. Having the location of it plotted on his board, Boesch saw that it was burning in an open area near Bald Top. Lots of grass in there and down lodgepole. Likely that was the cause of its fast spread.

"This is one for you, Clarence," Boesch said to the brush crew foreman. He didn't send all of Lindquist's crew with him. Those brush men were all skilled fire fighters and could act as straw-bosses on project fires. He let Lindquist take one of those with him, then gave him three of Smith's boomer crew—good men, but a little less experienced than the regular crew men.

"I'm going to put in an order for smokejumpers on that one, too," Boesch told Lindquist. "Be sure and take a radio with you."

The headquarters guard would get them outfitted with what they needed. Boesch stayed at the fire desk. He now called the forest dispatcher. He had quickly made out a smokejumper request form, and he gave Smith the necessary information for relay on to the regional office. That fire was already close to a half acre, so he ordered eight jumpers, a Ford Tri-Motor load.

"Wind's kicking up," Smith told him. "They might not be able to jump."

"I know," Boesch said, "But, I've got a five-man ground crew on the way."

Smith agreed that was a good idea—the old insurance business. Then he told Boesch he had four more of his boomer crew who would soon be ready to start for Darby. He would keep recruiting. West Fork now had two fires going, even though they'd had less lightning than Darby.

INTERDISTRICT TEAMWORK

Then the Sula District dispatcher was calling. He'd pulled his brush crew in—wanted to know if Darby wanted the five men.

"Send them right away," Boesch said, "and thanks, Terry."

The patrol plane was calling Darby now. He hadn't made it to that Tin Cup fire yet. Instead, the observer had spotted another

fire just above Lake Como in the Rock Creek drainage. This one, too, looked bad. Boesch knew that country well. He knew it was steep as a cow's face there. The fire was burning about half way up the slope. If it reached the top it would have bad fuels and would spread all over the country. Wasn't doing much yet, for the fuels were light where it had started. Just one snag burning. But the wind was throwing sparks from that snag. And when it fell, the burning tree would likely roll down to the creek bottom where there were more bad fuels.

Boesch called Smith. He asked if the rest of that boomer crew had got started for Darby.

"No," Smith said, "but they're ready to leave now. Got five of them with their own transportation."

This was good news. Boesch asked Smith to tell the men not to come to Darby, but instead to wait at the Lake Como road for the crew he was sending from Darby. They would go to the fire up Rock Creek.

Ward Mountain called then. He could see the Rock Creek fire throwing up smoke now—couldn't see it before because of a high ridge that shut him off. That one was beginning to spot, Boesch knew. Then he had Ward Mountain give him a report on the Bald Top fire.

"Doesn't seem to be spreading so fast now," was the word.

Boesch told him to watch for that jumper plane. Probably, he thought, the fire had made its initial run through the grass. But there was a lot of down lodgepole in the area. It would need a chain saw. He made a note of that.

Rock Creek was one for the assistant ranger, Bernie Swift. Boesch gave him two of Smith's boomer crew, one of whom was of strawboss caliber. Then Swift left, taking a handi-talkie, extra loose tools—enough to give each man a pulaski and shovel—and smokechaser rations.

"I'll get the rest of the stuff you'll need in to you, Bernie," Boesch said as the assistant went out the door, "one way or another."

A HELICOPTER JOINS THE FIGHT

The forest dispatcher was calling on the radio.

"Mark, what about the helicopter at Missoula? Possibly you can use it to stop the head of that Rock Creek fire."

"Fine, Tom," Boesch said happily. "We can sure use it. Have the pilot set down here at Darby."

"Will do," Smith said.

The headquarters guard went out to the wide area back of the ranger station to mark a set-down spot for the 'copter. This was not the first time the 'copter had been called for this kind of duty.

Now, the patrol plane was calling. There were two fires up Tin Cup. One of them, the one Deer Mountain had seen, was on a ridge top. It wasn't as much of a threat as one lower down, about a mile away. This one was beginning to spread in bad fuels.

"Swing down the canyon over the trail camp," Boesch ordered the observer. "Henderson will get on the radio. Give him that dope, and ask him to take the rest of his crew up there."

"10-4," came the acknowledgment. Then the observer added, "I tossed out some of Tom's pink toilet paper to mark those fires."

"Good dope," Boesch said, and smiled. But humorous or not, he knew the value of this. This scheme worked wonderfully in helping ground men find a fire. The pink color of the toilet paper could be seen a long distance as it unraveled itself earthward. And it marked an area well as it spread out over the trees and rocks.

Having a minute, Boesch called both restaurants in town and asked them to start making double lunches.

Now, Medicine Point, one of the Sula District lookouts, was calling Darby. He had just picked up a fire in Chaffin Creek. Just one snag burning. Boesch plotted its location quickly on his board—about a mile from the end of the road. Two good smokechasers could get there within an hour. He sent one man from Smith's boomer crew, plus one of the brush crew men. He decided not to send a radio with them. They could use the streamers in their smokechaser packs for signaling the plane if they needed anything. Ordinarily they would take a radio, but this one looked fairly easy, and Boesch wanted to hold a radio or two in reserve for higher priority.

Ranger Foskette came in just as Deer Mountain was reporting another fire. This one was in the head of Sleeping Child, near Coyote Meadows. This was high lodgepole country. The fire wasn't doing much, but it could. Plotting its location, Boesch saw it was not more than a mile from the East Side trail crew's location. He gave them orders through Deer Mountain to proceed to the fire. They had smokechaser packs with them, plus their radio. In about half-an-hour he would know the story on that one.

Ranger Foskette was busy reading the log the office clerk had been keeping as Boesch was busy working the fires. Darby now had six fires going, but also had men on the way to all of them.

"That Rock Creek fire worries me," the ranger said. "Maybe I'd better head up there."

"The 'copter will be here shortly, Red," Boesch told his ranger. "Why don't you use it to scout?"

"Good idea," Foskette said. "I'll go over, grab a quick lunch, then be all set."

The headquarters guard was busy. He had detailed several of the men standing by for fire duty to begin making up more smokechaser packs. Boesch could now hear the patrol plane talking to Alternate Henderson, giving him the word about the two Tin Cup fires. He heard Henderson 10-4 on taking the rest of the men up there, then get promptly off the air. Boesch got on the radio and asked the plane to swing over for another look at Rock Creek.

Now, Ward Mountain was on the air, calling in another fire, this one up Skalkaho. It was close to the Tenderfoot logging road. A bad area—logging slash in there, and open yellow pine country,

the fire burning on a south slope. It was beginning to spread. This was one for Bill Helm, the headquarters guard, a man with lots of fire experience. Before dispatching him, Boesch checked with Smith to see if he'd been able to recruit any more men.

"I've got two here," Smith said. "But, I've also got Stevensville's five-man brush crew coming. Figured you would need them. They should be here at Hamilton in about 10 minutes."

"That's fine, Tom. Send those seven men out to the Skalkaho road turnoff. Bill Helm will meet them there with the necessary tools."

Stevensville was the district north of Hamilton. Smith, as forest dispatcher, was doing his job of coordinating the Bitterroot Forest forces, helping to cope with this threat on the Darby District.

Boesch sent two of the experienced Sula men with Helm, along with a ten-man loose tool outfit, and had them stop at one of the restaurants to pick up ten double lunches. They could eat part of those lunches on the way to the fire. Helm also grabbed a chain saw, one of his favorite weapons.

It was 1230. Darby now had seven fires going.

Ward Mountain called. The jumper plane was over the Bald Top fire. Rock Creek was kicking up more smoke. Boesch called one of the sawmills. He spoke to the foreman who promised to have a ten-man crew ready for instant use when needed. Another sawmill promised the same. Both crews would have their own overhead.

Now, the patrol plane called. He couldn't get on the air earlier because of the traffic. He had scouted that Rock Creek fire carefully. The snag had fallen and rolled nearly a quarter of a mile downhill, setting spot fires along the way.

"You've got about six different fires burning there now," the observer reported. "Some are still spots. But two of them are spreading out. That country's mighty steep. No chance for jumpers." The observer should know. He was an exsmokejumper.

Now, Smith was calling from Hamilton. He'd talked to the Ford Tri-Motor that was circling Bald Top. Too much wind up there at the present time. They couldn't risk letting the men drop to that one.

There were eight good fire fighters in that plane. Boesch wanted to get them into action. "Ask them to swing over Tin Cup," he said to Smith. "Maybe they can jump on the lower fire. We'll have trouble there if it starts to crown."

"Will do," Smith said.

Then Boesch called the patrol plane. "Go over and have a look at Bald Top. Find where that ground crew is, and see if they'll be able to handle it."

"10-4."

COOPERATORS CALLED IN

It was 1245.

Would there be any more fires showing up? Boesch thought so. That's why he had held smokechasers in reserve. And he still had

cooperators to call on—individuals he had alerted earlier. Ranger Foskette was back from lunch. He got a refresher from the log, then went out to where the helicopter was setting down, taking a radio with him.

Boesch was on the phone again, calling one of the dude packers, Jack Lykins, and asking him to load his mules and take them to Lake Como to where the trail took off for Rock Creek. He made several other calls. These to other cooperators—men who owned boats with outboard motors. He asked them to get their boats and motors to Lake Como right away. In 15 minutes they could make a trip from one end of the lake to the other, saving Lykins 5 miles of packing. Then he had the packer-truckdriver take several men to help him load one of the 25-man outfits onto the truck. He would haul it to Lake Como and the stuff would be loaded onto the boats, then taken up to where Lykins could start packing. Bernie Swift and his men had been able to take a short cut around the rugged side of the lake. But there was no short cut for the mule string. They would have to use the good trail around the far side of the lake. But once at the head of the lake they would only have to pack that 25-man outfit a mile or so to where it was needed.

The patrol plane called then to say that the ground crew was about 15 minutes away from the Bald Top fire, and it looked like they could handle it. It was just about one-half acre in size.

Boesch told the plane to go look at the fire near Coyote Meadows, then swing over for a look at Skalkaho. But just then the trail crew called from Coyote Meadows, saying they had just got there and could handle the fire.

That was one of them, anyway, Boesch thought. He called Medicine Point to see how Chaffin Creek was doing. Still that one snag smoking. Those two smokechasers should just about be there, Boesch thought. When there was time, he would have the patrol plane swing over for a look at it.

The patrol plane was calling again. Another fire, this one in Little Sleeping Child Creek. It wasn't more than a mile from the Patterson Ranch. Al Patterson was a per diem guard and had a tool cache. Quickly Boesch called him and gave him the necessary information on the fire.

"You can grab your tools and get started for that one, Pat," Boesch told the per diem guard. "I'll call the Lovely boys and have them come up to give you a hand."

The Lovely brothers had a ranch about a mile below Patterson's. They'd been alerted earlier that morning and were standing by. Now they loaded two saddle horses onto their stock truck and in a few minutes were on the way. That fire would be manned by three capable cooperators in less than an hour. They were trained men who could put the fire out and return home without further instructions.

Ranger Foskette was now calling on the radio. It was only 20 minutes since he had walked out of the office, but already the helicopter had set him down on a large flat rock above those Rock Creek fires.

"Going to need about ten men up here, Mark," Foskette told his dispatcher. "I've sent the 'copter back to start ferrying them in. With luck we can handle this situation. I've just talked with Bernie below me. He's been trying to get out to you, but he must be boxed in. He's putting his men on the fires below. This is goat country. Worst fuel is up here on top. But I think we can keep those fires from getting up this high."

"Will it be safe working up there, Red?" Boesch asked.

"Yeah, it's okay," Foskette said. "Fuels are scattered there below us. Worst danger is for Bernie and his boys, from rolling rocks. I've warned him about them."

Now, Smith was calling from Hamilton. He'd just heard from the jumper plane over Tin Cup. Wind was a lot better there. They could put all eight of those jumpers on the lower fire.

"The spotter says it looks like they can use them down there, too," Smith told Boesch. "That lower fire is a couple acres and wanting to go. The upper fire is maybe a quarter of an acre, and is burning down slope. About four men can hold it."

That tricky wind, Boesch thought. It was true of a lot of those rugged west side canyons. Normally, fires burned a lot faster upslope this time of day, but in places like Tin Cup, the wind could really fool you. He gave Smith a quick go-ahead on putting the jumpers in. Good to get those huskies into action.

Now, the patrol plane was calling from Skalkaho.

"This fire is spreading pretty fast," Boesch was told. "It's in that yellow pine now. Must be 3 acres anyway. Looks like you'll need some followup."

"Can you see anything of Helm and his crew?" Boesch asked.

"Yeah, they're on the road. They've got about a mile to go yet. Should be on the fire in 20 minutes.

Boesch cleared, then got busy. He called one of the sawmills and got their ten-man crew headed for the ranger station. They would be there in 10 minutes. Then he called another mill and got their ten-man crew headed for the station. They'd be there shortly, too. One of these he would put on Rock Creek via helicopter. The other would go as reinforcements to Skalkaho.

Skalkaho was a dozer chance, too. He got one from a logger, working about 5 miles away. He could walk his dozer up the Tenderfoot road. He got another dozer from another logger, then called the County road department for their transport to haul it. Both dozers would be on the fire in 2 to 3 hours.

The packer-truckdriver was back from Lake Como now. The other 25-man outfit was loaded onto his truck, and he was soon off for Skalkaho.

"MOVE UP" OF FORCES PAYS OFF

Boesch still had seven good smokechasers and fire fighters left at his headquarters. Past experience had taught him that this was necessary. The day wasn't over yet. There would likely be

more fires showing up. And there was lots of work for those men right here at headquarters, keeping stuff moving, and running the numerous errands.

And so it went, with two more fires picked up later that afternoon, one by the patrol plane, the other by one of the lookouts. One of these fires was in remote back country. Boesch used two jumpers on that one, getting them on the fire within an hour and a half of the call, whereas it would have taken ground men 6 to 8 hours to get there. The other fire was closer in and Boesch put four of the seven reserves on it.

By nightfall every fire on the Darby District was manned. Several were under control. Skalkaho was 5 acres, but Helm was sure he would have it under control by the 10 o'clock deadline the next morning. Those two dozers had saved his men a lot of tough line building. Boesch had ordered a drop of tools, grub, and beds for the Tin Cup men. Henderson had the drop site marked. Among other things, he'd had them drop a pump with 4,000 feet of hose. The pump with 500 feet of hose could be used on the lower fire which was near the creek. The rest of the hose was used on the upper fire. Avery Hughes, one of the trail crew men, had worked out an ingenious system of gravity feed from a water source high up in the goat rocks. No pump was needed. All they had to do was start that water from the pot hole into the hose which ran down the steep hill. That gave them plenty of pressure. It was a system the Darby District had been using with great success for several years now. Henderson expected to have his Tin Cup fires controlled by the 10 o'clock deadline, too.

Rock Creek was six small fires spread out over a steep slope, the largest just under an acre in size. The 'copter had put all ten of the mill crew up there to help Ranger Foskette. He and his assistant working below had the situation under control. Lindquist and his crew held the Bald Top fire to an acre. The threat of project fires was over. Ten fires from one storm were held down to six Class A and four Class B.

Darby District, thanks to good beforehand thinking and preparedness, with the dispatcher using his meter to estimate rate of spread for slope exposure and fuels, which gave him a good idea of manpower and equipment needs, plus willing and able cooperators, and good teamwork on the part of forest and district headquarters, had again come through a tough situation, keeping the small ones from becoming big ones.

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INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

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